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PAPERS AND PROCEEDINGS OF THE ROYAL SOCIETY OF TASMANIA
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TASMANIA

UNIVERSITY OF TASMANIA

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NEW SPECIES OF *OPECHONA* LOOSS, 1907 AND *CEPHALOLEPIDAPEDON* YAMAGUTI, 1970 (DIGENEA: LEPOCREADIIDAE) FROM FISHES OFF NORTHERN TASMANIA

by Rodney A. Bray and Thomas H. Cribb

(with one text-figure)

BRAY, R.A. & CRIBB, T.H., 2003 (19:xii): New species of *Opechona* Looss, 1907 and *Cephalolepidapedon* Yamaguti, 1970 (Digenea: Lepocreadiidae) from fishes off northern Tasmania. *Papers and Proceedings of the Royal Society of Tasmania* 137: 1–5. ISSN 0080-4703.
Department of Zoology, Natural History Museum, Cromwell Road, London SW7 5BD, UK (RAB*); Centre for Marine Studies and Department of Microbiology and Parasitology, University of Queensland, Brisbane, Queensland 4072, Australia (THC). *Author for correspondence.

Two new species of lepocreadiid trematodes are described from teleost fishes from off the coast of northern Tasmania. *Opechona kahawai* sp. nov. from *Arripis* sp. (Arripidae) differs from congeners by a combination of a longer prepharynx, longer excretory vesicle and the genital pore antero-sinistral to the ventral sucker. *Cephalolepidapedon warehou* sp. nov. from *Seriolella punctata* (Centrolophidae) differs from its only congener in the vitellarium reaching into the posterior forebody, a heavy concentration of eye-spot pigment in the forebody, a relatively narrower and more elongate body, a longer prepharynx and a more distinct oesophagus.
Key Words: *Opechona, Cephalolepidapedon, Arripis, Seriolella,* Digenea, Lepocreadiidae, Tasmania.

INTRODUCTION

We have recovered two lepocreadiine species from the perciform fishes *Arripis* sp. (non *georgiana*) and *Seriolella punctata* (Forster, 1801) from the waters off northern Tasmania. According to records in the Host-Parasite database at the Parasitic Worms Division at the Natural History Museum, London, and a database produced at the Department of Microbiology and Parasitology, University of Queensland, neither species, indeed neither genus, has been reported as hosts of lepocreadiids before. Examination of these two forms has shown that they are undescribed and are, therefore, described as new.

MATERIALS AND METHODS

Digeneans collected from freshly-killed fish were fixed by being pipetted into nearly-boiling saline and immediately preserved in formalin. Whole-mounts were stained with Mayer's haematoxylin, cleared in methyl salicylate and mounted in Canada balsam. Measurements were made through a drawing tube on an Olympus BH-2 microscope, using a Digicad Plus digitising tablet and Carl Zeiss KS100 software adapted by Imaging Associates, and are quoted in micrometres as ranges and means in parentheses. Sucker-width ratio is given with the oral sucker width as one. The following abbreviations are used: BMNH, the British Museum (Natural History) collection at the Natural History Museum, London, UK; QM, Queensland Museum collection, Brisbane, Australia.

RESULTS

Family Lepocreadiidae Odhner, 1905
Subfamily Lepocreadiinae Odhner, 1905
Genus *Opechona* Looss, 1907
Opechona kahawai sp. nov.
Fig. 1A, B

Type material

Holotype: QM G221984, ex *Arripis* sp. (either *trutta* or *truttacea*) (Perciformes: Arripidae). Intestine. Off Stanley, Tasmania (40°46'S, 145°20'E, Dec. 1999).
Paratypes: QM G221985-221988, BMNH 2003.7.23.34-35, same data as holotype.

Description

Based on seven whole-mounts, four of which are mature. Body elongate, more or less parallel-sided, widest at oral sucker, bluntly rounded posteriorly, 3718–5307 × 315 × 473 (4205 × 359); width 7.8–9.0 (8.5)% of length (fig. 1A). Tegument spinose; spines in regular rows, reach to close to posterior extremity; rows less regular close to posterior extremity. Eye-spot pigment scattered around posterior part of oral sucker and prepharynx. Oral sucker large, widely-flared funnel-shaped, terminal, 403–545 × 370–489 (451 × 411). Ventral sucker small, oval, pre-equatorial, on slight protuberance 125–147 × 124–157 (132 × 136). Forebody 1599–2230 (1786) long, 40–44 (42)% of length. Sucker-width ratio 1:0.32–0.36 (1: 0.33). Prepharynx distinct, 97–177 (134) long. Pharynx small, subglobular, 97–137 × 103–133 (111 × 119). Pharynx to oral sucker width ratio 1:3.08–3.68 (1:3.46). Oesophagus lined with tegument, short, 11–42 (31) long. Pseudoesophagus (gastrodermis-lined) wider than oesophagus, 777–1068 (877) long, 19–79 (37) times as long as oesophagus. Intestinal bifurcation just anterior to ventral sucker; anterior point of bifurcation 127–217 (162) from ventral sucker. Caeca narrow anteriorly, wider in post-testicular region, form uroproct at posterior extremity by opening into wide chamber at base of excretory vesicle.

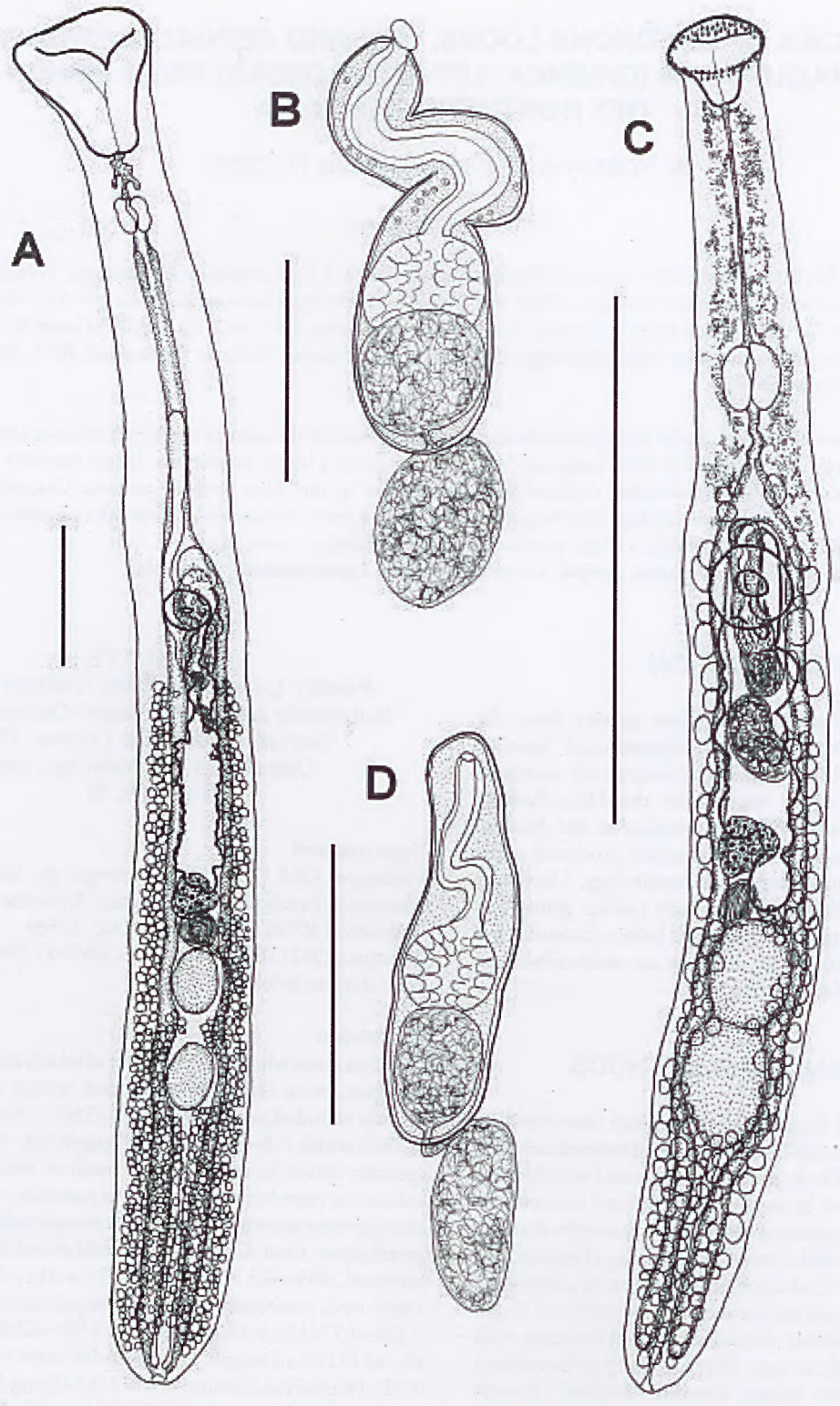

FIG. 1 — (A, B) Opechona kahawai *sp. nov. (A) Ventral view of holotype, uterus in bold outline, tiny tegumental spines not shown; (B) Cirrus-sac. (C, D)* Cephalolepidapedon warehou *sp. nov. (C) Ventral view of holotype, uterus in bold outline, tiny tegumental spines not shown; (D) Cirrus-sac. Scale-bars: A, C, 500 µm; B, 200µm; D, 100 µm.*

Testes two, tandem, oval, entire, slightly to distinctly separated by 4–100 (43), in mid-hindbody; anterior 215–269 × 167–200 (241 × 181), posterior 216–288 × 172–203 (252 × 188). Post-testicular region 686–1022 (799) long, 18–20 (19)% of body-length. External seminal vesicle coiled, tubular, reaches 305–400 (340) into hindbody, 43–53 (51)% of ventral sucker to ovary distance. Cirrus-sac of typical *Opechona*-type, claviform, convoluted, reaches well into hindbody, 365–500 × 108–127 (433 × 121) (fig. 1B). Internal seminal vesicle subglobular to oval. Pars prostatica vesicular, subglobular, lined with anuclear cell-like bodies, towards proximal end of cirrus-sac. Ejaculatory duct long, convoluted, muscular. Genital atrium distinct. Genital pore close to antero-sinistral margin of ventral sucker.

Ovary subglobular, virtually entire, but with evidence of three lobes separated by 69–111 (85) from anterior testis, median, 105–168 × 114–170 (137 × 136); 573–924 (683) from ventral sucker. Seminal receptacle canalicular, saccular, mainly dorsal to ovary. Mehlis' gland dorsal to ovary. Laurer's canal opens dorsally to left caecum at about level of anterior margin of anterior testis. Uterus preovarian, intercaecal. Eggs not highly numerous, tanned, operculate, 75–87 × 38–46 (83 × 41). Metraterm about half length of cirrus-sac; musculature develops gradually along length. Vitellarium follicular; fields reach into anterior hindbody, 75–191 (143) from ventral sucker; mainly lateral to caeca, encroach between testes, confluent dorsally and ventrally in post-testicular region.

Excretory pore terminal. Excretory vesicle I-shaped, initially a wide chamber at point where caeca join, then passes forward dorso-dextrally to testes, ovary and uterus, and reaches to mid-level of pseudoesophagus or slightly anterior; distal part lies ventrally to pseudoesophagus.

Discussion

Bray & Gibson (1990) reviewed *Opechona* Looss, 1907 and related genera. *Opechona* was characterised within the Lepocreadiinae by the presence of a uroproct, a pseudoesophagus and a typical '*Opechona*-type' cirrus-sac. They gave a key to those species that they considered definite members of the genus and also a key to those species which were possibly members of the genus, but which lacked some detail in the descriptions. In the first key our material from *Arripis* sp. comes closest to *O. occidentalis* Montgomery, 1957, an elongate form from scorpaenid fishes in the northeast Pacific Ocean. *Opechona occidentalis* differs in that the genital pore is at the posterior margin of the ventral sucker, the sucker ratio is much greater, the pseudoesophagus is only eight or nine times as long as the oesophagus and the excretory vesicle reaches only to the bifurcal level (Montgomery 1957). In addition, the eggs are larger in *O. kahawai* sp. nov. In the key to possible *Opechona* species, *O. kahawai* is closest to *O. formiae* Oshmarin, 1965 from formionids, stromateids and leiognathids in the northwest Pacific Ocean. In the latter species the caeca are figured as ending blindly, the sucker-ratio is distinctly greater, the prepharynx is longer and the genital pore is sinistro-lateral to the ventral sucker (Oshmarin 1965). Bray & Cribb (1998) erected a further species of *Opechona*, *O. austrobacillaris* Bray & Cribb, 1998 from *Pomatomus saltatrix* off both the eastern and western coasts of Australia. This is similar to *O. kahawai*, but differs in sucker-ratio (1:0.50–0.72) and in the pseudoesophagus being only 7–20 times the length of the oesophagus. Other species of *Opechona* erected since the review of Bray & Gibson (1990) are *O. dongshanensis* Wang & Wang, 1993 from *Upeneus sulphureus* off China, *O. gaevskayae* Ahmad, 1991 from *Fistularia villosa* in the Arabian Sea and *O. glossoides* Wang, 1989 from *Megalaspis cordyla* off China. A uroproct is not described in any of these species (Wang 1989, Ahmad 1991, Wang & Wang 1993). *Opechonis dongshanensis* and *O. glossoides* also differ from *O. kahawai* in the anterior extent of the vitelline fields, which reach into the forebody in the former and reach to the ventral sucker in the latter. In *O. gaevskayae* the vitellarium is restricted to the hindbody, but the oral sucker is 'spherical' and the sucker ratio 1:1, the pseudoesophagus is only about three times longer than the pharynx and the excretory vesicle reaches only to the bifurcal level. Thus *O. kahawai* possesses a unique suite of characters which we believe justifies the erection of a new species.

Etymology

'Kahawai' is a common name of the host used in Australia and New Zealand (Froese & Pauly 2003).

Genus *Cephalolepidapedon* Yamaguti, 1970
Cephalolepidapedon warehou sp. nov.
Fig. 1C, D

Type material

Holotype: QM G221968. ex *Seriolella punctata* (Forster) (Perciformes: Centrolophidae). Intestine. Off Stanley, Tasmania (40°46'S, 145°20'E, Dec. 1999). Paratypes: QM G221969–221983, BMNH 2003.7.23.27–33, same data as holotype.

Description

Based on 23 whole-mounts. Body elongate, slightly wider in hindbody, rounded posteriorly, 994–1503 × 115–163 (1294 × 143); width 9.5–14 (11)% of length (fig. 1C). Tegument spinose; spines in regular rows in forebody, sparse or absent in hindbody; anterior 2–3 rows slightly, but distinctly, enlarged, appearing as rows of circum-oral spines. Eye-spot pigment copious, scattered throughout parenchyma of forebody and to about posterior margin of ventral sucker. Oral sucker funnel-shaped, with narrow posterior protuberance, terminal, 73–93 × 79–98 (83 × 88). Ventral sucker small, rounded, pre-equatorial, on slight protuberance; 65–92 × 66–99 (76 × 78). Forebody 393–576 (481) long, 31–40 (37)% of length. Sucker-width ratio 1:0.83–0.96 (1:0.89). Prepharynx long, 133–285 (196) long. Pharynx large, oval, 52–67 × 50–62 (60 × 55). Pharynx to oral sucker width ratio 1:1.4–2.0 (1:1.6). Oesophagus lined with tegument, short, 18–119 (66) long. Intestinal bifurcation just anterior to ventral sucker; anterior point of bifurcation 47–104 (75) from ventral sucker. Caeca terminate blindly, 12–53 (35) from posterior extremity.

Testes two, tandem, oval, entire, contiguous or very slightly separated by 0–1.15 (0.08), in mid-hindbody; anterior 64–136 × 58–100 (100 × 83); posterior 75–167 × 60–106 (119 × 88). Post-testicular region 200–269 (234) long, 16–21 (18)% of body-length. External seminal vesicle saccular, reaches 107–258 (154) into hindbody, 60–95 (82)% of ventral sucker to ovary distance; distal narrow, recurved duct reaches to cirrus-sac. Cirrus-sac of typical *Opechona*-type, claviform, convoluted, reaches into hindbody, 130–218 × 34–54 (181 × 43) (fig. 1D). Internal seminal vesicle subglobular to oval. Pars prostatica vesicular, subglobular, lined with anuclear cell-like bodies, in proximal half of cirrus-sac. Ejaculatory duct long, convoluted, muscular. Genital atrium small. Genital pore antero-sinistral

to ventral sucker.

Ovary subtriangular, contiguous or slightly separated by 0–45 (23) from anterior testis, slightly dextral, 46–78 × 40–72 (62 × 58); 125–299 (189) from ventral sucker. Ventral sucker to ovary distance 11–21 (15)% of body-length. Seminal receptacle canalicular, saccular, in dorsal plane between ovary and anterior testis or dorsal between junction of them. Mehlis' gland dorsal to ovary. Laurer's canal opens dorsally to left caecum or sinistral edge of anterior testis, at about level of anterior third of anterior testis. Uterus pre-ovarian, mainly intercaecal. Eggs relatively few (c. 3–19), tanned, operculate, 52–63 × 27–37 (58 × 32). Metraterm distinct, muscular, reaches from about posterior edge of ventral sucker. Vitellarium follicular; fields reach into posterior forebody, 29–124 (74) from ventral sucker; mainly lateral to caeca; in ventral plane scattered follicles may overlie uterus, encroach over testes slightly and be confluent ventrally in post-testicular region; in dorsal plane follicles encroach caeca only slightly at level of gonads and fields are separated by excretory vesicle in post-testicular region.

Excretory pore terminal. Excretory vesicle I-shaped, narrow, reaches to anterior part of post-testicular region or just overlaps posterior testis.

Discussion

The general morphology of the type, and only, species of *Cephalolepidapedon*, *C. saba* Yamaguti, 1970, is similar to other lepocreadiines, but differs from most by the rows of slightly-enlarged spines around the aperture of the oral sucker. These are not greatly enlarged, as is found, for example, in the acanthocolpid genera *Stephanostomum* Looss, 1899 or *Stephanostomoides* Mamaev & Oshmarin, 1966, or other lepocreadiids, such as *Acanthogalea* Gibson, 1976, but are similar to those of *Clavogalea* Bray, 1985. *Cephalolepidapedon* is distinguished from *Clavogalea* by its blind-ending caeca and lack of a pseudoesophagus, although the pseudoesophagus in *Clavogalea* may be insignificant, as in the type-species *C. gaevskayae* Bray, 1985 (Bray & Gibson 1990) or much longer than the oesophagus, as in *C. trachinoti* (Fischthal & Thomas, 1968) (see Bray & Cribb 1998). Yamaguti (1970) described *C. saba* as having a long excretory vesicle reaching to the pharynx, but examination of the 'type-series' and new material by Shimazu (1989) has shown it to be short, 'barely reaching to posterior testis'. The specimens described here are considered members of *Cephalolepidapedon* because they have the following suite of characters: slightly-enlarged oral spines, blind caeca, lack of a pseudoesophagus, short excretory vesicle and funnel-shaped oral sucker.

Cephalolepidapedon saba (syns *Stephanostomum tristephanum* of Zhukov (1960); *S. scombri* Korotaeva, 1974; *Opechona acanthoris* Gaevskaya & Aleshkina, 1985; *Lepocreadium misakiensis* Shimazu, 1986) has been found in two species of *Scomber*, but from a geographically wide area, that is, *S.* [= *Pneumatophorus*] *japonicus* off Hawaii (Yamaguti 1970), in the Sea of Japan (Shimazu 1986; Shimazu 1989; Zhukov 1960), in the East China Sea (Shen 1986), in the Yellow and Bo Hai seas (Shen & Qiu 1995) and in the southeastern Atlantic (Gaevskaya & Aleshkina 1985), and in *S. australasicus* from the Great Australian Bight (Korotaeva 1974). The species has also been reported from off Hainan Island in the South China Sea, but the host is not given (Shen & Li 2000). The species has been described several times (Zhukov 1960; Yamaguti 1970; Korotaeva 1974; Gaevskaya & Aleshkina 1985; Shimazu 1986; Shimazu 1989; Shen & Qiu 1995). *Cephalolepidapedon warehou* sp. nov, is morphologically similar to *C. saba*, but can be distinguished by the vitellarium reaching into the posterior forebody, the heavy concentration of eye-spot pigment in the forebody, a relatively narrower and more elongate body, a longer prepharynx and a more distinct oesophagus. In *C. saba* the vitellarium is restricted to the hindbody, reaching anteriorly only as far as the middle of the ventral sucker to ovary distance. The illustrations in Zhukov (1960), Yamaguti (1970) and Shimazu (1986) show scattered eye-spot pigment, but it is much less widely distributed than in *C. warehou*, being confined to the area between the oral sucker and the pharynx.

Etymology

Silver or Spotted 'Warehou' are common names of the host used in Australia and New Zealand (Froese & Pauly 2003).

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REFERENCES

AHMAD, J., 1991: A new genus and three new species of digenetic trematodes from marine fishes of Arabian Sea. *Pakistan Journal of Zoology* 23: 99–104.

BRAY, R.A. & CRIBB, T.H., 1998: Lepocreadiidae (Digenea) of Australian coastal fishes: new species of *Opechona* Looss, 1907, *Lepotrema* Ozaki, 1932 and *Bianium* Stunkard, 1930 and comments on other species reported for the first time or poorly known in Australian waters. *Systematic Parasitology* 41: 123–148.

BRAY, R.A. & GIBSON, D.I., 1990: The Lepocreadiidae (Digenea) of fishes of the north-east Atlantic: review of the genera *Opechona* Looss, 1907 and *Prodistomum* Linton, 1910. *Systematic Parasitology* 15: 159–202.

FROESE, R & PAULY, D., 2003: Fishbase. World Wide Web electronic publication: www.fishbase.org.

GAEVSKAYA, A.V. & ALESHKINA, L.D., 1985: New species of trematodes from the eastern Atlantic. *Parazitologiya* 19: 105–112. (In Russian.)

KOROTAEVA, V.D., 1974: [Helminths of some commercial marine fish of the sub-order Scomberoidei from the Australian region]. *Izvestiya Tikhookeanskogo Nauchno Issledovatel'skogo Instituta Rybnogo Khozyaistva i Okeanografii (TINRO)* 88: 61–66.

MONTGOMERY, W.R., 1957: Studies on digenetic trematodes from marine fishes of La Jolla, California. *Transactions of the American Microscopical Society* 76: 13–36.

OSHMARIN, P.G., 1965: [On the trematode fauna of marine and freshwater fishes of Vietnam.] *In* Leonov, A.A., Mamaev, Y.L. & Oshmarin, P.G. (Eds): *Parasitic worms of domestic and wild animals.* Akademiya Nauk SSSR, Vladivostok: 213–249. (In Russian.)

SHEN J., 1986: Digenetic trematodes of fishes from the east China Sea I. Species of the families Opistholebetidae, Lepocreadiidae and Cryptogonimidae. *Studia Marina Sinica* 27: 209–219.

SHEN J.-W. & LI X.-H., 2000: Addendum to the parasite digenetic trematodes from marine fishes in Hainan Island. *Studia Marina Sinica* 42: 153–162. (In Chinese.)

SHEN J.-W. & QIU Z.-Z., 1995: *Studies on the trematodes of fishes from the Yellow Sea and the Bo Hai Sea.* Science Press,

Beijing, 207pp. (In Chinese.)

SHIMAZU, T., 1986: *Lepocreadium misakiense* sp. n. and *Neopechona olssoni* (Yamaguti, 1934), comb. n. (Trematoda: Lepocreadiidae), parasites of a Japanese marine fish, *Scomber japonicus*. *Zoological Science* 3: 569–571.

SHIMAZU, T., 1989: Taxonomic notes on *Cephalolepidapedon saba* and *Opechona orientalis* (Trematoda: Lepocreadiidae) of the marine fish, *Scomber japonicus* (Teleostei: Scombridae). *Japanese Journal of Parasitology* 38: 232–235.

WANG P.-Q., 1989: Digenetic trematodes of marine fishes in Pingtan County, Fujian Province, South China. *Wuyi Science Journal* 7: 151–163. (In Chinese.)

WANG P.-Q. & WANG Y.-Y., 1993: Some digenetic trematodes of marine fishes from Fujian Province. *Journal of Fujian Normal University, Natural Science* 9: 66–73. (In Chinese.)

YAMAGUTI, S., 1970: *Digenetic trematodes of Hawaiian fishes*. Keigaku Publishing Co., Tokyo, 436 pp.

ZHUKOV, E.V., 1960: Endoparasitic worms of the fishes in the Sea of Japan and South-Kuril shallow-waters. *Trudy Zoologicheskogo Instituta, Leningrad* 28: 3–146. (In Russian.)

(accepted 28 July 2003)

PARASITIC WORMS IN REPTILES FROM TASMANIA AND THE ISLANDS OF BASS STRAIT

by Hugh I. Jones

(with two text-figures and one table)

JONES, H.I., 2003 (19:xii): Parasitic worms in reptiles from Tasmania and the islands of Bass Strait. *Papers and Proceedings of the Royal Society of Tasmania* 137: 7–12. ISSN 0080-4703. Department of Microbiology, University of Western Australia, Nedlands, Western Australia 6009, Australia.

The endoparasitic worms in reptiles from Tasmania and the islands of Bass Strait were recorded from dissections of nine *Tympanocryptis diemensis*, six *Tiliqua nigrolutea*, 20 *Cyclodomorphus casuarinae*, 15 *Egernia whitii*, 17 *Austrelaps superbus*, 24 *Notechis ater*, seven *Drysdalia coronoides* and four *Pelamis platurus*. Thirteen species of worms were recorded, namely, the pentastomes *Waddycephalus superbus* and *Waddycephalus* ?sp. nov., an unidentified oxyurid nematode species, the nematodes *Maxvachonia brygooi, M. chabaudi, Strongyluris paronai, Moaciria* sp., *Paraheterotyphlum australe, Ophidascaris pyrrhus, Kreisiella* sp., *Abbreviata antarctica*, the trematode *Dolichoperoides macalpini* and the cestode *Oochoristica vacuolata*. The roundworm *O. pyrrhus* was most prevalent, occurring almost entirely in the Black Tiger Snake, *N. ater*. The fluke *D. macalpini* was found, often at high intensity, in the Black Tiger Snake and in the Copperhead, *A. superbus*. No other worms occurred in more than two of any host species, and, apart from *A. antarctica* and *S. paronai*, all nematodes were at an intensity of four or less worms per host. Six of the 13 helminth species were recovered only from the Bass Strait islands. Previous studies in mainland Australia demonstrate that the reptile species examined in the present study (*N. ater*), or related species in the same genera (*Tiliqua, Cyclodomorphus, Egernia, Drysdalia*), may support a greater range and number of nematodes. The possible reasons for the lower worm numbers in Tasmania include the effects of a cool and damp climate on the distribution of the worms' intermediate hosts and on the survival of free-living stages of the parasites, and geographical isolation.

Key Words: Tasmania, reptiles, pentastomes, nematodes, cestodes, trematodes.

INTRODUCTION

Tasmania and the Bass Strait islands possess a depauperate reptile fauna. This is a consequence of their cool-temperate to cold-temperate climate and periods of isolation from the Australian mainland during interglacial periods (Rawlinson 1974). During the last ice age, Tasmania was joined by a land-bridge to Australia for a period of about 7000 years from 21 750 to 14 750 years BP, and the Tasmanian climate would have been colder than at present (Rawlinson 1974). Seventeen species of terrestrial reptile occur in Tasmania: one agamid lizard *(Tympanocryptis diemensis* (Gray, 1841)), 13 scincid species (of which the nine species in the genus *Pseudomoia* are closely-related small skinks, confined principally to southeastern Australia (Cogger 1992)), and the snakes *Austrelaps superbus* (Günther, 1841), *Notechis ater* (Krefft, 1866) and *Drysdalia coronoides* (Günther, 1858) (Elapidae). In addition, *Pelamis platurus* (Linnaeus, 1766), the most widely-distributed of sea snakes, is occasionally washed up on Tasmanian shores.

Several species of helminth have been recorded from reptiles in Tasmania, but there has not hitherto been a systematic survey of reptilian helminth parasites. Information on the pathology caused to reptiles in the wild by such parasites, and the effects such morbidity may have on the hosts' survival, is limited. This study was undertaken to ascertain the species of worms present, their prevalence and geographical distribution within Tasmania, and the relation of these parameters to the same or related hosts on the Australian mainland.

MATERIAL AND METHODS

In total 86 reptiles, representing six species of lizard, all three terrestrial endemic snakes and one species of sea snake, were examined in the collections of the Tasmanian Museum and Art Gallery in Hobart (TMAG) and the Queen Victoria Museum and Art Gallery in Launceston (QVMAG). In addition, nematodes from three *Notechis ater* and one *Austrelaps superbus* were identified from specimens in the Australian National Wildlife Collection (housed in CSIRO Sustainable Ecosystems in Canberra), and the records from another ten *N. ater* and two *A. superbus* in the same collection, all collected from Bass Strait islands, were forwarded by Dr D. M. Spratt. All species of Tasmanian and Bass Strait reptiles except the small skinks in the genera *Pseudomoia* (eight species), *Lerista bougainvillii* (Gray, 1839) and *Eulamprus tympanum* (Lönnberg & Andersson, 1913) (which is confined in this region to a single Bass Strait island, Rodondo Island, close to the Victorian mainland), were examined.

Material dissected

Agamidae: *Tympanocryptis diemensis* (TMAG: C25, C50, C195, C196; QVMAG: Q1986.3.53, Q1972.3.112, Q1972.3.112, Q1981.3.90, Q1981.3.28), Scincidae: *Tiliqua nigrolutea* (Quoy & Gaimard, 1824) (TMAG: C128, C321, C392, C805, C1000, C1001), *Cyclodomorphus casuarinae* (Duméril & Bibron, 1839) (TMAG: C44, C115, C116, C117, C120, C121a, C121b, C122, C123, C126, C258, C273, C305, C318, C329, C333, C1/377; QVMAG: Q1969.3.8, Q1969.3.13, Q1979.3.39), *Egernia whitii* (Lacépède, 1804) (QVMAG: Q1970.3.80 (three specimens), 1962.3.29, 1990.3.5, 1990.3.6, 1990.3.7. 1990.3.25, 1990.3.26, 1990.3.28, 1990.3.56, 1990.3.57, 1990.3.58, 1990.3.59, 1990.3.60), Elapidae: *Austrelaps superbus* (TMAG: C153, C154, C157, C160, C162. C163, C165, C330, C340,

C809; QVMAG: Q1972/3/191, Q1973/3/9, Q1973/3/21, Q1986A), *Notechis ater* (TMAG: C271, C272, C131, C132, C144, C145, C146, C147, C148, C149; QVMAG: Q1958/3/13), *Drysdalia coronoides* (TMAG: C20, C166, C171, C172, C166, C324; QVMAG: Q1988/3/16), and Hydrophiidae: *Pelamis platurus* (TMAG: C173, C174, C176, C325). From CSIRO, nematodes were examined from one *A. superbus* (N3188) and from three *N. ater* (N3187, N2852a and 2852b); helminth and collection data of these hosts and of *N. ater* PM 96/87 (four snakes), PM 157/87 (two snakes), PM 69/88 (five snakes) and *A. superbus* PM85/90 and 86/90, are included. The reptile hosts had been collected predominantly from the settled areas in or close to Hobart (including South Bruny Island), towns on the north coast, Maria Island on the east coast, and Flinders, King, Chappell, Passage and Sisters islands in Bass Strait.

Accession numbers of worms examined

Ophidascaris pyrrhus: TMAG K2797, K2798, K2799, K2800, K 2801; QVM 18:3965; CSIRO N2852a, 2852b. *Paraheterotyphlum australe*: TMAG K2802, K2803. *Moaciria* sp: TMAG K2796. *Maxvachonia chabaudi* QVM 18:3963, 18:3964. *Abbreviata antarctica*: CSIRO N3187, N3188. *Dolichoperoides macalpini*: TMAG K2804, K2805, K2806, K2807, K2808; QVM 18:3966, 18:3967, 18:2968, 18: 3969, 18:3970, 18: 3971. *Waddycephalus superbus*: QVM 10:25348.

All specimens had been fixed in 10% formaldehyde and preserved in 70% ethanol; some were in poor condition, thus affecting the recovery of parasites. All worms recovered from the internal organs were cleaned. Nematodes and pentastomes were cleared for examination in chlorolactophenol and stored in 70% alcohol with 10% glycerine. Trematodes were stained using Chubb's stain (Chubb 1962). Lungs from three *A. superbus* (hosts C809, 1086A, 1973/3/21) with attached trematodes *Dolichoperoides macalpini*, and the stomach of one *N. ater* (C144) with burrowing *Ophidascaris pyrrhus* were serially sectioned at 5µ, and stained with haematoxylin and eosin. Helminths have been returned to their respective collections. Reptile nomenclature follows Cogger (1992).

RESULTS

In all 36 reptiles (36.7%) were infected with parasitic worms, of 13 species. These comprised two pentastomes, one cestode, one trematode and nine species of nematode. The findings were as follows (see table 1).

Waddycephalus superbus Riley & Self, 1981 (Pentastomida: Porocephalidae) was recovered from the lungs of three Copperhead snakes, *A. superbus*, in numbers from 2–7, from King Island (one host) and Flinders Island (two hosts). Seven specimens of an apparently unknown species of *Waddycephalus* were recovered from a Black Tiger Snake, *N. ater*, from Lucrana, Flinders Island.

Oxyuridae ?gen., ?sp. Three immature and female nematodes in poor condition in the family Oxyuridae were found in each of two Oak Skinks, *Cyclodomorphus casuarinae*, from Maria Island and from near Hobart. Four and two female *Maxvachonia chabaudi* Mawson, 1972 (Nematoda: Cosmocercidae) were recovered respectively from 2/15 White's Skink, *Egernia whitii*, examined, from Passage Island, Bass Strait, and a single *M. brygooi* Mawson, 1972 was collected from *A. superbus* from Emita on Flinders Island. A single female *Moaciria sp.* (Nematoda: Heterakidae) was recovered from the skink *E. whitii* from Chappell Island, and one female from the skink *C. casuarinae* from Hobart.

One male and one immature female *Paraheterotyphlum australe* Johnston & Mawson, 1948 (Nematoda: Anisakidae)

TABLE 1
Parasitic worms recovered from eight species of reptile from Tasmania and Bass Strait islands

	Hosts							
Parasites	*Tympano-cryptis diemensis* (N: 9)	*Tiliqua nigrolutea* (N: 6)	*Cyclodo-morphus casuarinae* (N: 20)	*Egernia whitii* (N: 15)	*Austrelaps superbus* (N: 17)	*Notechis ater* (N: 24)	*Drysdalia coronoides* (N: 7)	*Pelamis platurus* (N: 4)
Waddycephalus superbus					2*			
Waddycephalus ?sp. nov.						1		
Oxyuridae ?gen. ?sp.			2					
Maxvachonia brygooi					1			
Maxvachonia chabaudi				2				
Strongyluris paronai					1			
Moaciria sp.			1	1				
Paraheterotyphlum australe								2
Ophidascaris pyrrhus					1	16		
Kreisiella sp.	1				2			
Abbreviata antarctica					2			
Dolichoperoides macalpini					8	8		
Oochoristica vacuolata				2	1			

* Numbers refer to the number of reptiles infected with each species of helminth.

were recovered from 2/4 sea snakes, *Pelamis platurus,* which had been recovered from the shores of Flinders Island (one) and beaches in southern and southeastern Tasmania (three).

Ophidascaris pyrrhus Johnston & Mawson, 1942 (Nematoda: Ascarididae) was both the most prevalent nematode recovered and, by virtue of its size, the most conspicuous. It was present in 16/24 *N. ater* examined. All hosts on the Tasmanian mainland (including Bruny Island) and 5/12 *N. ater* from Chappell Island were infected (fig. 1). It was also recorded in a single *A. superbus,* from West Point Lighthouse in northwestern Tasmania, and appears to be distributed throughout the island. Most were threaded through the stomach wall, with the two ends within the stomach lumen, and as a result many could not be recovered entire. Numbers present ranged from one to 24, and their lengths were up to 150 mm.

A single female *Kreisiella* sp. (Nematoda: Physalopteridae) was collected from a dragon lizard, *Tympanocryptis diemensis,* from near Devonport, northern Tasmania. Its suboptimal condition and the absence of males precluded identification to species.

Abbreviata antartica von Linstow, 1899 (Nematoda: Physalopteridae) infected two snakes from Flinders Island: one *Austrelaps superbus* from Emita contained 57 worms, and one *N. ater* from Lucrana contained 15 worms.

Dolichoperoides macalpini (Nichol, 1918) (Trematoda: Dolichoperidae) was confined to two species of snake, occurring in 8/17 *A. superbus* and 8/24 *N. ater.* This trematode also had a wide geographical distribution, including King and Flinders islands (fig. 2), although it was absent from all 12 *N. ater* collected on Chappell Island. Most worms were present in the lungs and trachea, with smaller numbers in the upper oesophagus and stomach (possibly due to movements after death of host). Numbers ranged from two to >50.

The tapeworm *Oochoristica vacuolata* Hickman, 1954 (Cestoda: Anoplocephalidae) was recovered from 2/15 *E. whitii* examined, from Chappell Island in Bass Strait, each lizard having two worms in the intestine and from one *A. superbus.*

Pathology

Sections of stomach from *N. ater* containing transverse sections of *O. pyrrhus* revealed that the tunnels of these worms lie in the submucosa. They were surrounded by concentric layers of collagen fibres, with little cellular infiltration, which extended to and replaced the overlying mucous membrane lining the stomach lumen.

No midline dorso-ventral sections of *D. macalpini* were obtained from segments of lung from three *A. superbus.* A thin layer of mucus surrounded the worms, and in two cases there was a large effusion of blood around the worms. The normal ciliated pseudostratified epithelium of the smaller bronchiole lining was replaced, when in contact with the spinous epidermis of the trematode, with flattened squamous cells. Apart from one small clump of lymphocytes adjacent to one worm, there was no appreciable histiocyte or other inflammatory cell infiltration, or any fibrous proliferation. Haemolysed blood was present in the oral sucker cavity of one worm.

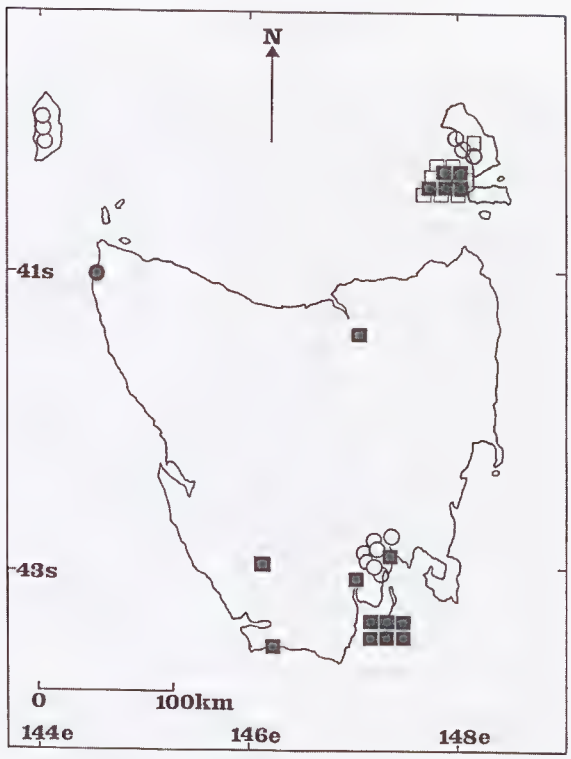

FIG. 1 — Distribution of the nematode Ophidascaris pyrrhus *in the Black Tiger Snake* Notechis ater *(squares) and in the Copperhead* Austrelaps superbus *(circles). Black, infection present; white, no infection (no locality data were available for three* A. superbus*).*

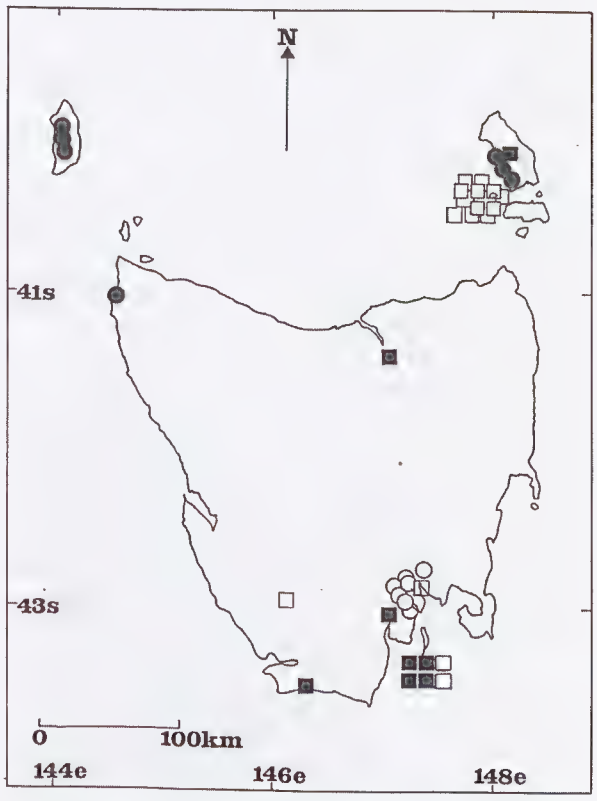

FIG. 2 — Distribution of the fluke Dolichoperoides macalpini *in the Black Tiger Snake* Notechis ater *(squares) and in the Copperhead* Austrelaps superbus *(circles). Black, infection present; white, no infection (no locality data were available for three* A. superbus*).*

DISCUSSION

The pentastome *A. superbus*, the trematode *D. macalpini* and the cestode *O. vacuolata* have all been reported previously from Tasmania, and *W. superbus* and *O. vacuolata* were described from there. *W. superbus* is found only in Tasmanian and Bass Strait island populations of *A. superbus* (Riley *et al.* 1985), and was minutely described by Spencer (1893), under the name of *Pentastomum teretiusculum*, from this species of snake from King Island. *Oochoristica vacuolata* was described from *E. whitii* from Hobart by Hickman (1954), who found it to be common in this host species in Tasmania.

Ophidascaris pyrrhus appears to be widespread in Australian elapid snakes in southern Australia. It was described from *Pseudechis porphyriacus* from New South Wales (Johnston & Mawson 1942), and an ascarid nematode presumed to be this species was collected from *A. superbus* in Victoria (McAlpine 1891a). Jones (1980) reported it from several species of elapid snakes in Western Australia, mainly in the more temperate southwest of that state, and found, as in the present study, that *N. ater* had the highest prevalence and intensity of infection.

The low infection of reptiles collected in the vicinity of Hobart may indicate that intermediate hosts of the parasites are present in diminished numbers or are absent in this ecologically-perturbed environment.

Other species of parasitic worms appear to be uncommon in these species of reptile in Tasmania. Mawson (1972) commented that *Maxvachonia* is geographically widespread but nowhere common, and these findings bear out this observation; *M. chabaudi* has been most commonly recorded from skinks, including *E. whitii* from South Australia (Mawson 1972), and *Ctenotus uber* and *Unechis nigriceps* from Victoria and South Australia (Watherow, pers. comm.). *M. brygooi* occurs in *Cyclodomorphus branchialis* in Western Australia (Jones 1992). These are the first records of this genus from Tasmania.

Three species of *Moaciria* have been described from Australia, all from the west (Jones 1979); one was recovered from a skink and two from snakes (which may have been spurious infections). It has also been reported from Papua New Guinea (Gibbons 1979, Jones 1983). The two infected skinks reported here, *C. casuarinae* and *E. whitii*, are new host and geographical records.

The two oxyurids from *C. casuarinae* could not be identified to species. The oxyurid nematodes *Pharyngodon tiliquae* Baylis, 1930, *P. australis* Johnston & Mawson, 1942 and *Thelandros trachysauri* Johnston & Mawson, 1947 have been previously reported from the skink genera *Tiliqua* and *Cyclodomorphus* in southern and eastern Australia, and *P. tiliquae*, *T. trachysauri* and *Parapharyngodon fitzroyi* from these two skink genera in Western Australia (Jones 1992). A female *Kreisiella* sp. was described from New Britain by Kreis (1940), under the name *Physaloptera heterocephala*, from *Gonyocephalus modestus* (Agamidae). It is widespread in smaller lizards, principally skinks, in Western Australia (Jones 1995), achieving highest numbers in *Egernia inornata*. This record extends the known geographical and host range of the nematode.

Nematodes in the genus *Abbreviata* were not recovered from any reptiles in mainland Tasmania; only two snakes were found infected on Flinders Island. *Abbreviata* species are widespread on the Australian mainland among larger reptiles, and although they attain highest prevalence and intensity in the hot dry inland areas of Australia in the larger species of *Varanus* monitor lizards (which are absent from Tasmania and the Bass Strait islands), they are widespread in *V. varius* and *V. gouldii* in southern and cooler areas of the mainland, including Kangaroo Island (Johnston & Mawson 1941; Jones unpub. data). They also occur in the larger elapid snakes, including *N. ater* (2/23) and *Drysdalia coronata* (4/22) in Western Australia (Jones 1978). Larval physalopterids, presumed to be predominantly *Abbreviata* spp., are a conspicuous finding in a wide variety of smaller reptiles in mainland Australia (Jones 1995), but none was seen in the present study. No *Abbreviata* were recovered from *T. nigrolutea*, but *A. antarctica* is present at high prevalence (79%) and intensity in the related *T. scincoides* in Western Australia, mainly in the southwest (Jones 1992). The presence of nematodes of this genus in the same species of reptile (*N. ater*) or reptile species in the same genus (*Drysdalia coronata*, *T. scincoides*), on the Australian mainland, therefore indicates that the absence of *Abbreviata* spp. from mainland Tasmania is not due to the absence of suitable reptile hosts. Their absence may be related to the absence or scarcity of suitable intermediate hosts, to the inability of free-living (egg) stages to survive in the cooler, wetter climate, or to the lower abundance of susceptible reptile hosts (Rawlinson 1974) for transmission to occur. This cannot be ascertained until life-cycles have been elucidated for species of *Abbreviata* in Australia.

Paraheterotyphlum australe was described from *Pelamis platurus* by Johnston & Mawson (1948), and re-described by Sprent (1978). It also occurs in several other sea snakes, whose principal diet is fish, and which are probable intermediate hosts.

Dolichoperoides macalpini is a common parasite of *N. scutatus* in southeastern Australia. The mention of trematodes present in "vast numbers in the trachea and gullet" of *A. superbus* taken in Victoria (McAlpine 1891b) probably refers to this species. It occurs principally in swampy areas in Tasmania, and its life-cycle, which involves the snails *Ameria* spp. and frogs *Limnodynastes* spp., was elucidated by Johnston & Angel (1940) from specimens collected on Flinders Island. Its absence from all 12 *N. ater* collected on Chappell Island is interesting, and may indicate the absence of frog intermediate hosts on this island, but this cannot be ascertained.

Apart from the nematode *O. pyrrhus* in *N. ater*, and the trematode *D. macalpini* in this snake and in *A. superbus*, the reptiles in this region display a low prevalence, intensity and diversity of parasitic helminths. Six of the 13 species of worms (two *Waddycephalus* spp., *Maxvachonia brygooi*, *M. chabaudi*, *Strongyluris paronai* and *Abbreviata antarctica*) were recorded only in the Bass Strait islands (though *W. superbus* occurs in Tasmania; Riley *et al.* 1985). This is of interest as Flinders and others islands in the Furneaux Group are considerably more distant from the mainland than from Tasmania, the climate is not markedly more benign than in northeastern Tasmania, and it is believed that both Tasmania and the Bass Strait islands have been separated from continental Australia for similar periods of time (Hope 1974). However, the samples, both of hosts and of parasites, are relatively small, and further studies are necessary to validate and amplify these findings. It is probable that *M. brygooi* and *S. paronai*, which are found predominantly in smaller lizards, were spurious infections in *A. superbus* on Flinders Island, and were acquired from their prey. No helminths were found in two reptiles species

examined (*Tiliqua nigrolutea* and *Drysdalia coronoides*), and a single worm was recovered from *Tympanocryptis diemensis*. The same or closely-related reptile species on the Australian mainland often support a more diverse nematode fauna, with higher prevalence and intensity of infection. A comparable systematic study of the helminth fauna of reptiles in climatically similar areas of the adjacent mainland may shed light on the relative importance of climate and isolation in determining the composition and prevalence of parasitic worms in Tasmania's reptiles.

Since the large snakes examined in this study are kept in captivity for the production of antivenenes, diseases which may affect their venom production have long been known. Fairley & Splatt (1929) reported that the fluke *Dolichopera* (=*Dolichoperoides*) *macalpini* is the most serious infection encountered, leading to emaciation, anaemia and sometimes death of the snakes in captivity. It is assumed (though it is not possible to ascertain) that all the snakes examined in the present study had been caught in the wild. None had the appearance of being emaciated, and the extent to which infection with *Dolichoperoides* or *Ophidascaris* adversely affects their health in the wild remains problematical, despite the fact that seven *N. ater* and one *A. superbus* had concurrent infection with both species of worm.

CONCLUSIONS

The reptile fauna of Tasmania and the islands of Bass Strait displays low prevalence and intensity of parasitic worms. This is probably a consequence of several factors; the reptiles themselves exhibit low species diversity, and the abundance of these ectotherms in the cool and wet climate of Tasmania may itself be less than on the adjacent mainland, and thus influence the chances of parasite transmission. The common trematode *D. macalpini* requires amphibian intermediate hosts and so could be expected to thrive in this climate. The life-cycle of the other common parasite, *O. pyrrhus*, is not known, though it is widespread throughout the southern, and cooler and wetter, parts of mainland Australia. Therefore until more is known of the life-cycles of the worms, especially the species and distribution of intermediate hosts, and the relative effects of climate and geographical isolation on their biology, further conclusions cannot be drawn.

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REFERENCES

Chubb, J. C., 1962: Acetic acid as a diluent and dehydrant in the preparation of whole, stained helminths. *Stain Technology* 37: 179–182.

Cogger, H. G., (1992): *Reptiles and Amphibians of Australia.* Fifth edition. Reed International Books, Chatswood, NSW: 775 pp.

Fairley, N. H. & Splatt, B., (1929): Venom yields in Australian poisonous snakes. *Medical Journal of Australia* 1: 336–448, March 16, and fig. XI following p. 306, March 9.

Gibbons, L. M., 1979: *Moaciria chondropythonis* sp. n. (Heterakidae; Spinicaudinae), a nematode from a Papuan tree python, *Chondropython viridis*. *Journal of Helminthology* 53: 301–306.

Hickman, J. L., 1954: Two new cestodes (Genus *Oochoristica*), one from the lizard, *Egernia whitii*, the other from the bat, *Nyctophilus geoffroyi*. *Papers and Proceedings of the Royal Society of Tasmania* 88: 81–104.

Hope, J. H., 1974: The biogeography of the mammals of the islands of Bass Strait. *In* Williams, W.D. (Ed.): *Biogeography and Ecology in Tasmania.* Junk, The Hague: 397–415.

Johnston, T. H. & Angel, L. M., 1940: The morphology and life history of the trematode, *Dolichopera macalpini* Nicholl. *Transactions of the Royal Society of South Australia* 64: 376–387.

Johnston, T. H. & Mawson, P. M., 1941: Some nematodes from Kangaroo Island, South Australia. *Records of the South Australian Museum* 7: 145–148.

Johnston, T. H. & Mawson. P. M., 1942: The Gallard collection of parasitic nematodes in the Australian Museum. *Records of the Australian Museum* 21: 110–115.

Johnston, T. H. & Mawson, P. M., 1948: Some new records of nematodes from Australian snakes. *Records of the South Australian Museum* 9: 101–106.

Jones, H. I., 1978: *Abbreviata* (Nematoda: Physalopteroidea) from Western Australian snakes. *Australian Journal of Zoology* 26: 789–807.

Jones, H. I., 1979: New species of *Moaciria* Freitas, 1956 (Nematoda: Heterakoidea) from Australian reptiles. *Journal of Helminthology* 53: 133–140.

Jones, H. I., 1980: Observations of nematodes from west and central Australian snakes. *Australian Journal of Zoology* 28: 423–433.

Jones, H. I., 1983: A collection of nematodes from snakes from Papua New Guinea. *Systematic Parasitology* 5: 131–134.

Jones, H. I., 1992: Gastrointestinal nematodes in the lizard genera *Tiliqua* and *Cyclodomorphus* (Scincidae) in Western Australia. *Australian Journal of Zoology* 40: 115–126.

Jones, H. I., 1995: Gastric nematode communities from lizards from the Great Victorian Desert, and an hypothesis for their evolution. *Australian Journal of Zoology* 43: 141–164.

Kreis, H. A., 1940: Beitrage zur Kenntnis parasitischer Nematoden. IX. Parasitische nematoden aus dem Naturhistorischen Museum Basel. *Zentralblatt fur Bakteriologie, Parasitenkunde und Infektionskrankheiten* 145: 163–208.

Mawson, P. M., 1972: The nematode genus *Maxvachonia* (Oxyurata: Cosmocercidae) in Australian reptiles and frogs. *Transactions of the Royal Society of South Australia* 96: 101–113.

McAlpine, D., 1891a: On a nematode found in the stomach of a copper-head snake. *Proceedings of the Royal Society of Victoria* 3: 38–39.

McAlpine, D., 1891b: Remarks on a fluke parasitic in the copper-head snake. *Proceedings of the Royal Society of Victoria* 3: 40–43.

Rawlinson, P. A., 1974: Biogeography and ecology of the reptiles of Tasmania and the Bass Strait area. *In* Williams, W.D. (Ed.): *Biogeography and Ecology in Tasmania* Junk, The Hague: 291–338.

RILEY, J., SPRATT, D. M., & PRESIDENTE, P. J. A., 1985: Pentastomids (Arthropoda) parasitic in Australian reptiles and mammals. *Australian Journal of Zoology* 33: 39–53.

SPENCER, W. B., 1893: The anatomy of *Pentastomum teretiusculum* (Baird). *Quarterly Journal of Microscopical Science* 34: 1–73.

SPRENT, J. F. A., 1978: Ascaridoid nematodes of amphibia and reptiles: *Paraheterotyphlum*. Supplementary review article. *Journal of Helminthology* 52: 163–170.

(accepted 28 July 2003)

PROTEROGYNOTAENIA DEBLOCKI SP. NOV. (CESTODA: PROGYNOTAENIIDAE) FROM THE RED-CAPPED PLOVER, *CHARADRIUS RUFICAPILLUS*, FROM KING ISLAND, TASMANIA

by John M. Kinsella and Albert G. Canaris

(with one text-figure)

KINSELLA, J. M., & CANARIS, A. G., 2003 (19:xii): *Proterogynotaenia deblocki* sp. nov. (Cestoda: Progynotaeniidae) from the Red-capped Plover, *Charadrius ruficapillus*, from King Island, Tasmania. *Papers and Proceedings of the Royal Society of Tasmania* 137: 13-15. ISSN 0080-4703. HelmWest Laboratory, 2108 Hilda Avenue, Missoula, Montana, USA 59801 (JMK*); and PO Box 717, Hamilton, Montana, USA 59840 (formerly Department of Biological Sciences, University of Texas at El Paso) (AGC). *Author for correspondence.

A new species of cestode, *Proterogynotaenia deblocki* (Progynotaeniidae), is described from the Red-capped Plover, *Charadrius ruficapillus*, from King Island, Tasmania. The new species is characterised by its longer strobila (18–28 mm), large number of proglottids (60–85), number and size of the hooks on the rostellum (six large hooks 33–39 µm long, six small hooks 13–15 µm long) and large number of testes (62–83), which are divided by the uterus into two groups.

Key Words: cestode, *Proterogynotaenia deblocki*, *Charadrius ruficapillus*, Red-Capped plover, King Island, Tasmania.

INTRODUCTION

The Red-capped Plover, *Charadrius ruficapillus* Temminck, 1822, is a non-migratory shorebird widespread in Australia, especially in the southern half, common in Tasmania, and occasionally reported from New Zealand. It is found in littoral, estuarine and terrestrial wetlands, especially in arid areas, and prefers saline and brackish waters, where it feeds on annelids, molluscs, small crustaceans and some plant material (Marchant & Higgins 1993).

In an earlier paper, we reported on the helminth parasite communities of four species of shorebirds, including the Red-capped Plover on King Island, Tasmania (Canaris & Kinsella 1998). The most prevalent helminth found in *C. ruficapillus* was an undescribed cestode of the genus *Proterogynotaenia* (17 of 20, 85%). Here we describe this new species.

MATERIAL AND METHODS

Red-capped Plovers (N = 20) were collected on King Island, Tasmania, under appropriate permits from 26 February to 8 March 1993. Birds were immediately placed in individual plastic bags, refrigerated and examined within six hours. Cestodes were relaxed in cold tap water, fixed in alcohol-formalin-acetic acid (AFA), stained in Semichon's acid carmine or Ehrlich's hematoxylin, cleared in clove oil and mounted in Canada balsam. Some scoleces were squashed and mounted in Hoyer's medium to obtain a more accurate measurement of the rostellar hooks. Data provided are ranges followed by means in parentheses. Measurements are in micrometres unless otherwise specified. Type specimens were deposited in the Helminth Collection of the South Australian Museum, Adelaide, Australia, and the United States National Parasite Collection, Beltsville, Maryland, USA.

TAXONOMY

Proterogynotaenia deblocki sp. nov. Fig. 1A–E

Description based on ten mature specimens

Gravid cestodes 18–28 (23) mm long, craspedote, apolytic, consisting of 60–85 (71) proglottids. Scolex (fig. 1A) 162–195 (187) long by 220–300 (267) wide. Suckers oval, 120–150 (134) long by 95–105 (100) wide. Rostellum up to 160 long when completely everted, bearing 12 hooks of two sizes that alternate irregularly in two circles; anterior hooks 33–39 (37) long, posterior hooks 13–15 (14) long, both with long, slender handle and small blade and slightly shorter guard (fig. 1B). Rostellar sac 160–265 (200) long by 60–80 (70) in maximum width, extending to level of posterior margins of suckers or slightly beyond. Neck short, 120–160 (137). Two dorsal and two ventral osmoregulatory canals with transverse connections in posterior end of each proglottid. Strobila proterogynous, develops very slowly; in one specimen with 67 proglottids, ovary and vitellarium first appear in proglottid 54 and are completely developed in proglottid 56; large seminal receptacle up to 240 in diameter appears in following proglottid while ovary disintegrates. Seminal receptacle, in turn, atrophies in next proglottid, but remnant can be seen in terminal proglottids. Ovary lobulate, composed of two posteriorly directed lobes joined by an anterior isthmus, 205–255 (228) long (fig. 1C). Vitellarium posterior to ovary and often surrounded by branches of ovary, rounded, 60–80 (73) in diameter. Testes mature in the next 3–4 proglottids after ovary disappears. Proglottids with fully mature testes and developing uterus 1070–1220 (1147) long by 590–970 (804) wide (fig. 1D). Testes arranged in two groups, separated by uterus, 24–35 (27) poral, and 39–56 (46) antiporal; total number ranges from 62–83 (74). Mature testes roughly spherical, 55–73 (59) in maximum diameter. Cirrus pouch in anterior half of proglottid, passing between longitudinal excretory canals, 440–545 long (453) by 120–150 (132) in maximum width. Coiled external and internal seminal vesicles present. Cirrus stout, strongly muscular, when fully everted is proximally

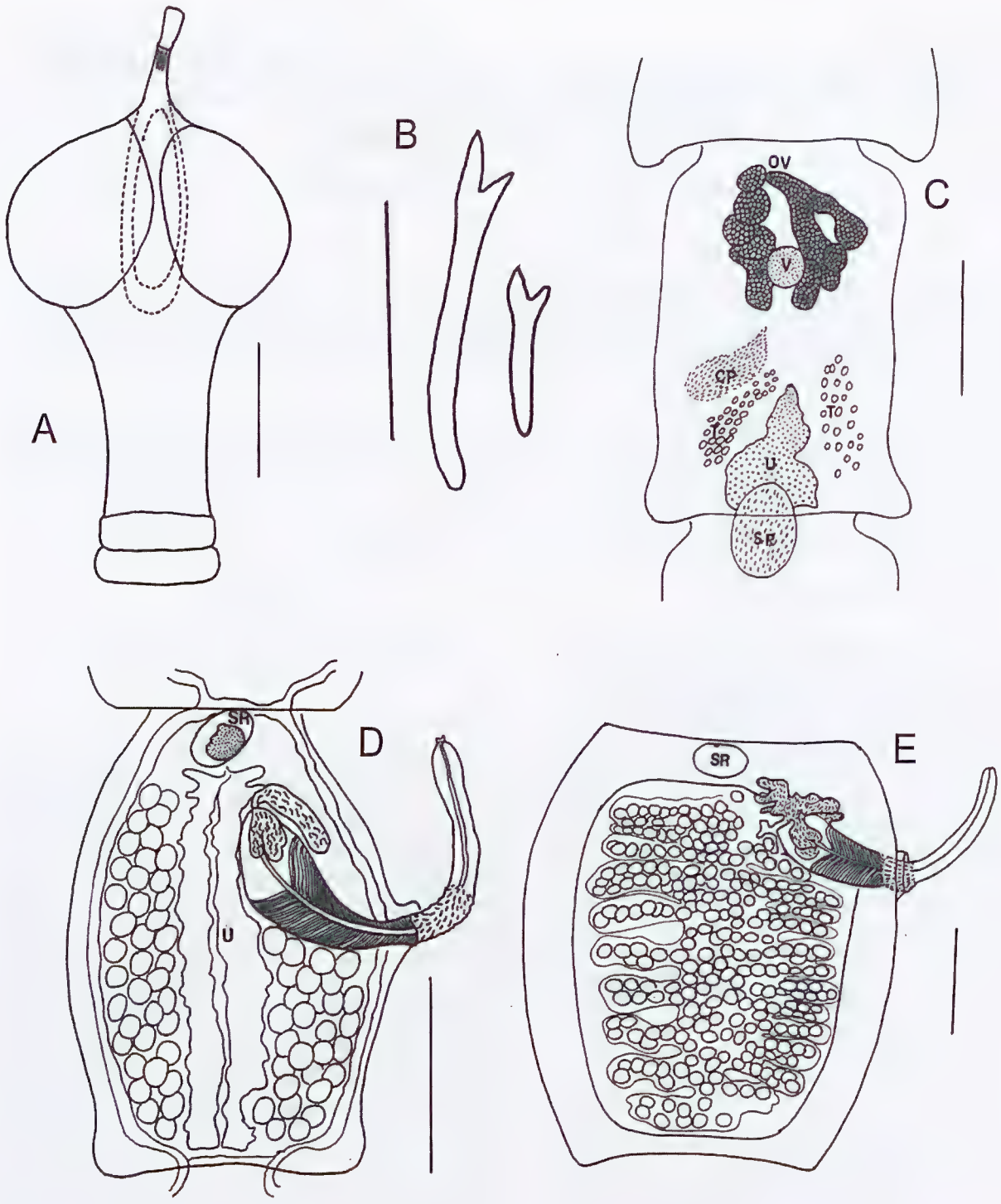


FIG. 1 — Proterogynotaenia deblocki *sp. nov. (A) Scolex and rostellum; (B) Rostellar hooks; (C) Proglottid with ovary and vitellarium developed; (D) Mature proglottid with testes, cirrus, and uterus developed; (E) Gravid proglottid. CP = developing cirrus pouch, OV = ovary, SR = seminal receptacle, T = testes, V = vitellarium, U = uterus. Scales: (A) 100 µm. (B) 25µm. (C) 500 µm. (D) 250 µm. (E) 500 µm.*

spined for first third and smooth distally, 410–505 (453) long (measuring from base of spines to end), projects from a genital papilla (fig. 1D). Genital pores irregularly alternating. In most specimens, only terminal proglottid has completely mature eggs. Gravid proglottids large (fig. 1E), about twice as long as wide, 1685–2245 (1982) by 860–1225 (991), uterus a median tube with 10–15 lateral branches on each side. Eggs round, 36–45 (41) in diameter, oncospheral hooks 10–12 in length.

Type host
Charadrius ruficapillus Temminck, 1822, Red-capped Plover.

Site of infection
Small intestine.

Prevalence and intensity
17 of 20 (85%) infected with 2–149 (mean 34).

Type locality
King Island, Tasmania.

Type specimens
Helminth Collection of the South Australian Museum, holotype No. 28529, paratypes Nos 28530–28532; U.S. National Parasite Collection, paratype No. 93985.

Etymology
Named in honour of Dr Stephane Deblock for his many contributions to the systematics of cestodes.

DISCUSSION

There are currently 12 species recognised in the genus *Proterogynotaenia*: *P. rouxi* Fuhrmann, 1911; *P. flaccida* (Meggitt, 1928); *P. haematopodis* (Davies & Rees, 1947); *P. neoarctica* Webster, 1951; *P. variabilis* Belopolskaya, 1953; *P. dougi* Sandeman, 1959; *P. polytestis* Belopolskaya, 1973; *P. branchiuterina* Belopolskaya, 1973; *P. texanum* Huey, 1985; *P. marcusae* Schmidt & Canaris, 1992; *P. paulinae* Schmidt & Canaris, 1992; and *P. tibori* Macko & Spakulova, 1995. Ryzhikov & Tolkacheva (1981) considered *P. branchiuterina* a synonym of *P. dougi*, but Macko & Spakulova (1995) re-examined the type material of *P. dougi* and concluded that differences in the cirrus armature and uterine shape between the two species justified retaining *P. branchiuterina* as a separate species.

Species of *Proterogynotaenia* are generally distinguished by total length, number of proglottids, number and size of rostellar hooks, and the number and distribution of testes (poral and antiporal) (Schmidt & Canaris 1992). Seven species (*P. flaccida, P. variabilis, P. dougi, P. polytestis, P. branchiuterina, P. texanum, P. tibori*) are all less than 7 mm long, with a maximum of nine proglottids per gravid worm. Of the larger species, only two, *P. rouxi* (15–20 mm) and *P. marcusuae* (22–26 mm), approach the length of gravid *P. deblocki* (18–28 mm). *Proterogynotaenia marcusae* has only 34–40 proglottids compared with 60–85 in *P. deblocki* and the testes of *P. marcusae* are not divided into two fields by the uterus, making it unique in the genus. Proglottids of *P. rouxi* number from 63–70, overlapping with *P. deblocki*, but the maximum reported length is 20 mm. In addition, *P. rouxi* has seven large and seven small rostellar hooks compared with six large and six small hooks in *P. deblocki*. The number of testes in *P. rouxi* (50) is also less than in *P. deblocki* (62–83).

The total number of hooks on the rostellum in this genus shows considerable variation, ranging from 12 in six species (*P. variabilis, P. polytestis, P. texanum, P. paulinae, P. marcusae, P. tibori*) to as many as 68 in *P. haematopodis*. Three of the species with 12 hooks (*P. polytestis, P. texanum, P. tibori*) have hooks in the same size range (33–40 and 13–18) as *P. deblocki* (33–39 and 13–15), but all are much smaller worms, with a maximum of nine proglottids.

Only three species overlap *P. deblocki* in numbers of testes: *P. haematopodis* with 50–130 testes, *P. marcusae* with 50–70 testes and *P. polytestis* with 72 testes. The first two species have been differentiated from *P. deblocki* (see above); mature *P. polytestis* are differentiated from *P. deblocki* by having fewer proglottids (8) and a much shorter length (2.2 mm).

To date, each species of *Proterogynotaenia* is known only from one species of host. In an earlier study of four species of shorebirds from King Island, *P. deblocki* had high prevalence (85%) in *C. ruficapillus*, but was absent in Masked Lapwings, *Vanellus miles* (Boddaert, 1782), Ruddy Turnstones, *Arenaria interpres* (Linnaeus, 1758), and Curlew Sandpipers, *Calidris ferruginea* (Pontoppidan, 1763) (Canaris & Kinsella 1998). Six species of *Proterogynotaenia* (*P. variabilis, P. branchiuterina, P. dougi, P. polytestis, P. texanum, P. tibori*) have been described from the same host, the Black-bellied Plover, *Pluvialis squatarola* (Linnaeus, 1758). More extensive collections from *P. squatarola* are needed to study the range of morphological variation and the validity of these species. Genetic studies would be particularly useful in answering these questions. It is important that future researchers preserve some specimens collected in ethanol for analysis of nucleic acid sequences.

It is noteworthy that the three species of *Proterogynotaenia* with the greatest lengths and largest numbers of proglottids are all from the southern hemisphere: *P. marcusae* from South Africa, *P. rouxi* from the Aru Islands and now *P. deblocki* from Tasmania. Again, genetic studies may show whether these species are closely related or if this is just a coincidence.

ACKNOWLEDGEMENTS

We wish to thank Nigel Burgess; Jamie Bayly-Stark, Assistant Director Wildlife; David Rounsevell, Wildlife Research Officer; Dr Steven Smith, Chief Zoologist, Department of Parks, Wildlife and Heritage, Tasmania; and Dr Michael Stoddart, University of Tasmania, for their help, courtesy and support in obtaining permits and collecting birds on King Island. Patricia A. Canaris assisted with fieldwork and prepared the final drawings.

REFERENCES

Canaris, A. G. & Kinsella, J. M., 1998: Helminth parasite communities in four species of shorebirds (Charadriidae) on King Island, Tasmania. *Papers and Proceedings of the Royal Society of Tasmania* 132: 49–57.

Macko, J. K. & Spakulova, M., 1995: Taxonomic study of some *Proterogynotaenia* tapeworms (Cestoda: Acoleata) from *Pluvialis* spp. (Charadriiformes) including a description of *P. tibori* sp. n. and a redescription of *P. dougi*. *Biologia, Bratislava* 50: 449–455.

Marchant, S. & Higgins, P. J. (Eds), 1993: *Handbook of Australian, New Zealand, and Antarctic Birds. Vol. 2: Raptors to Lapwings*. Oxford University Press, Melbourne: 984 pp.

Ryzhikov, K. M. & Tolkacheva, L. M., 1981: *Principles of Cestodology. Vol. 10. Acoleata-Cestodes of Birds*. Academy of Sciences, Moscow. [In Russian.]

Schmidt, G. D. & Canaris, A. G., 1992: Tapeworms of the families Progynotaeniidae Fuhrmann, 1936 and Dioecocestidae Southwell, 1930 from shorebirds of South Africa. *Systematic Parasitology* 23: 37–42.

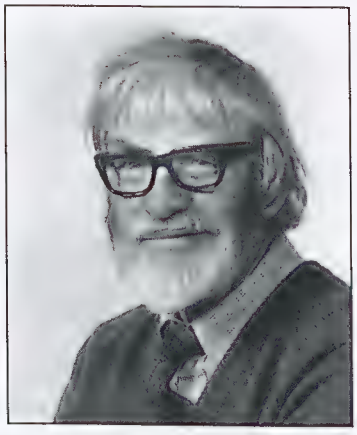
(accepted 29 September 2003))

OBITUARY
PROFESSOR WILLIAM DALZIEL JACKSON, 1921–2002

by James B. Reid

(with one plate)

Reid, J.B., 2003 (19:xii): Obituary Professor William Dalziel Jackson, 1921–2002. *Papers and Proceedings of the Royal Society of Tasmania* 137: 17–19. ISSN 0080–4703. School of Plant Science, University of Tasmania, Private Bag 55, Hobart, Tasmania 7001, Australia.



Emeritus Professor Bill Jackson

Emeritus Professor Bill Jackson is remembered as an academic, botanist, ecologist and geneticist. He was all of these things and much more. He was a truly inspirational teacher who made time available to students regardless of what else was on. An insightful researcher, he established the core principles of ecological theory that describe the processes shaping the Tasmanian vegetation. He was a leader and visionary who saw the way forward in botanical research and fostered its development over nearly 50 years. He was head of the Department of Botany at the University of Tasmania for over 20 years. Bill Jackson, or Prof as he was known by generations of students, led from the front and took the big decisions. The paperwork was left to others or the circular filing cabinet.

Prof was born in Hobart, Tasmania, in 1921. After completing an instrument-maker course at the Launceston Technical College, he served as an artificer with the AIF in the Pacific arena during WWII. He began his studies at the University of Tasmania in 1946 and graduated with a B.Sc. Honours degree in Botany in 1952. He joined the staff of the Botany Department as a Demonstrator in the same year. He completed his Ph.D. in 1960 under the supervision of Professor H. Newton Barber FRS. His thesis, as with all his research, included ground-breaking work on clinal variation in eucalypts and chromosomal damage from X-rays.

His work on eucalypts was ahead of his time (Jackson 1960) and, consequently, traditional taxonomists were reluctant to accept his view of the genetic continuum of clinal variation between species. We easily accept this concept today, but in the 1950s the concept of the immutability of species was still dogma, at least among many taxonomists who refereed his manuscripts. His work laid the foundations for many student projects in the following four decades and led to international recognition for the University of Tasmania as a centre for the genetic studies of eucalypts. He received the David Syme Medal for this research in 1960, a medal awarded by the University of Melbourne for the most distinguished science during the previous two years. Former students have spread far and wide, all enthused by Prof's deep and abiding interest in why variation occurs within and between plant species.

His other great passion was the love of the Tasmanian bush and his knowledge of its plant communities. His work laid the foundations for our current understanding of plant ecology in Tasmania. His insights into the role of fire and humans on our environment were extraordinary. They covered communities from dry, coastal areas, through our wet sclerophyll and rainforest regions to the alpine habitat (e.g., Jackson 1968, 1999b,c,d). He managed to see systems as dynamic and interactive. He understood probabalistic events and hence how chance events could shape plant communities. This he used to explain how wet sclerophyll communities developed and changed over time and led him to be active in the public debate over forests and forestry well before it became politically popular.

His influence was best seen through his legendary style and approach to his favourite course, Field Botany, which he established in the early 1970s and continues today. Students 30 years his junior could not keep up with him. He would be calling out species names and descriptions with vigour and enthusiasm from morning until after dusk. He would become absorbed with the plants and he would not stop for lunch until after 3 pm. The students would be feeling the pinch but if Prof could do it, how could they wilt? Tea

would be the same. Prof would keep going well past the normal cut-off time and then they would still have to walk back from the Tarn Shelf or K-Col or wherever they had ended up at the end of the day, getting back after dusk on numerous occasions. He was in his element telling stories around the camp-fire or in the hut at night, imparting knowledge and views about conservation and forestry to generations of students over a quiet drink.

Bill Jackson was appointed Professor of Botany and Head of Department in 1966 and he remained Head of Department until a year before his retirement in 1986. Over that period he built up the infrastructure of the Department in all the major areas for which the Department is recognised nationally today — eucalypt genetics, developmental genetics, ecology and algal studies. He would actively participate in the design and development of specialist facilities and we often joked that he was the highest paid technician in the University. One of the strangest examples was the cyclic salt collector, which was designed to test how much of the nutrient input to oligotrophic environments of west and southwest Tasmania came from rain and how much from the soil. You may have seen them around the state. Prof used his design expertise to help others examine problems.

This exemplified his leadership style. He identified potential in researchers and encouraged them and provided the resources necessary to make the research successful. His vision in this area is the main reason the Department of Botany was successful under his leadership and has continued to be successful years after his retirement. Many former students of the Department are indebted to his support and encouragement for their careers.

His dedication to the Department, University and its students did not end on retirement. Prof continued with his research right up until a few weeks before his death. Indeed he published a paper on nutrient ecology in 2000 (Jackson 2000) and one paper on a topic he began investigating over 40 years ago, the genetic variation in trigger plants, was published in 2001 (Jackson & Wiltshire 2001). In his retirement, he made substantial donations to the University to establish scholarships to allow future generations of students to undertake studies in botany and genetics. His generosity of time over his 56 years on campus also inspired many students to continue their studies.

He was active in departmental life right to the end. He would come to morning and afternoon tea for his game of crib and offer advice to staff and students. Prof will be remembered by generations of students as a great teacher, someone who always questioned why things were the way they were, someone who cared deeply for them and who always had the time available to discuss an issue or stay beyond the end of a practical class if others were interested. He was an inspirational Tasmanian who has made crucial and lasting discoveries on the nature of the Tasmanian vegetation and the factors that control its communities and their distribution. He always could see the broad overview — he was an integrator and ideas person.

In honour of Prof's contribution to botanical research in Tasmania, a public symposium was held in October 2002, under the auspices of the School of Plant Science, the Royal Society of Tasmania and the Ecological Society of Australia. Some of the proceedings of that symposium are presented in the following articles, prepared by his former students to commemorate his memory and to give a glimpse into two of the areas of botany that fascinated him. They cover the development of research on *Eucalyptus* and his role in it, and an overview of the cytological variation in the Tasmanian flora.

BIBLIOGRAPHY

Barber, H.N. & Jackson, W.D., 1957: Natural selection in action in *Eucalyptus*. *Nature* 179: 1267–1269.

Barber, H.N., Jackson, W.D. & Murfet, I.C., 1958: Gibberellic Acid and the physiological genetics of flowering in peas. *Nature* 182: 1321–1322.

Bowman, D.M.J.S. & Jackson, W.D., 1981: Vegetation succession in southwest Tasmania. *Search* 12: 358–362.

Duff, G.A., Reid, J.B. & Jackson, W.D., 1983: The occurrence of mixed stands of the *Eucalyptus* genera *Monocalyptus* and *Symphomyrtus* in south-eastern Tasmania. *Australian Journal of Ecology* 8: 405–414.

Harwood, C.E. & Jackson, W.D., 1975: Atmospheric losses of four plant nutrients during a forest fire. *Australian Journal of Forestry* 38: 92–99.

Jackson, W.D., 1958: Natural hybrids in eucalypts, Part I. *E. x taeniola* (*E. salicifolia x E. sieberiana*). *Papers and Proceedings of the Royal Society of Tasmania* 92: 141–146.

Jackson, W.D., 1958: Chromosome numbers in Tasmanian Goodeniaceae and Brunoniaceae. *Papers and Proceedings of the Royal Society of Tasmania* 92: 161–163.

Jackson, W.D., 1959: The three-dimensional or solid-image microscope. *Nature* 183: 1048–1049.

Jackson, W.D., 1959: The life-span of mutagens produced in cells by irradiation. *Radiation Biology:* 190–208.

Jackson, W.D., 1960: Clinal variation in *Eucalyptus vernicosa*. Part 1. Taxonomic treatment. Unpublished Ph.D. thesis, University of Tasmania.

Jackson, W.D., 1965: Vegetation. *In* Davies, J.L. (Ed.): *Atlas of Tasmania*. Lands and Surveys Department, Hobart: 30–35.

Jackson, W.D., 1968: Fire, air, water and earth, an elemental ecology of Tasmania. *Proceedings of the Ecological Society of Australia* 3: 9–16.

Jackson, W.D., 1968: Fire and the Tasmanian flora. *Tasmanian Year Book* 11: 50–55.

Jackson, W.D., 1973: Vegetation of the central plateau. *In* Banks, M.R. (Ed.): *The lake country*. Royal Society of Tasmania, Hobart: 61–86.

Jackson, W.D., 1974: Conservation in Tasmania. *In* Specht, R.L., Roe, E.M. & Broughton, V.H. (Eds): *Conservation of major plant communities in Australia and Papua New Guinea*. CSIRO, East Melbourne: 319–448.

Jackson, W.D., 1977: Nutrient cycling in Tasmanian oligotrophic environments. *In* Proceedings of a Symposium on Nutrient cycling and indigenous forest ecosystems, CSIRO, Perth: 122–123.

Jackson, W.D., 1978: Ecological drift: an argument against the continued practice of hazard reduction burning. *In* Gee, H. & Fenton, J. (Eds): *The South West Book*. Australian Conservation Foundation, Melbourne: 98–102.

Jackson, W.D. (Ed.), 1981a: *Vegetation of Tasmania*. University of Tasmania, Hobart.

Jackson, W.D., 1981b: The Tasmanian environment: climate. *In* Jackson, W.D. (Ed.): *Vegetation of Tasmania*. University of Tasmania, Hobart:1–4.

Jackson, W.D., 1981c: Vegetation. *In* Jackson, W.D. (Ed.): *Vegetation of Tasmania*. University of Tasmania, Hobart: 11–16

Jackson, W.D., 1981d: Fire-patterned vegetation. *In* Jackson, W.D. (Ed.): *Vegetation of Tasmania*. University of Tasmania, Hobart: 17–35.

Jackson, W.D., 1981e: Wet sclerophyll. *In* Jackson, W.D. (Ed.): *Vegetation of Tasmania*. University of Tasmania, Hobart: 68–72.

Jackson, W.D., 1983: Tasmanian Rainforest Ecology. *In* Blakers, R. & Robertson, P. (Eds): *Tasmania's Rainforests: What Future?* Australian Conservation Foundation, Hobart: 9–39

Jackson, W.D., 1999a: The Tasmanian legacy of man and fire. *Papers and Proceedings of the Royal Society of Tasmania* 133: 1–14.

Jackson, W.D., 1999b: Vegetation types. *In* Reid, J.B., Hill, R.S., Brown, M.J. & Hovenden, M.J. (Eds): *Vegetation of Tasmania.* Australian Biological Resources Study, Melbourne: 1–10.

Jackson, W.D., 1999c: The Tasmanian environment. *In* Reid, J.B., Hill, R.S., Brown, M.J. & Hovenden, M.J. (Eds): *Vegetation of Tasmania.* Australian Biological Resource Study, Melbourne: 11–38.

Jackson, W.D., 1999d: Palaeohistory of vegetation change: the last two million years. *In* J.B. Reid, R.S. Hill, M.J. Brown & M.J. Hovenden (Eds): *Vegetation of Tasmania.* Australian Biological Resources Study, Melbourne: 64–88.

Jackson, W.D., 2000: Nutrient stocks in Tasmanian vegetation and approximate losses due to fire. *Papers and Proceedings of the Royal Society of Tasmania* 134: 1–18.

Jackson, W.D. & Barber, H.N., 1958: Patterns of chromosome breakage after irradiation and ageing. *Heredity* 12: 1–25.

Jackson, W.D. & Bowman, D.M.J.S., 1982a: Slash burning in Tasmanian dry eucalypt forests: Comment. *Australian Forestry* 45: 63–67.

Jackson, W.D. & Bowman, D.M.J.S., 1982b: Reply: Ecological drift or fire cycles in south west Tasmania. *Search* 13: 175–176.

Jackson, W.D. & Brown, M.J., 1999: Pattern and process in vegetation. *In* Reid, J.B., Hill, R.S., Brown, M.J. & Hovenden, M.J. (Eds): *Vegetation of Tasmania.* Australian Biological Resources Study, Melbourne: 357–380.

Jackson, W.D. & Wiltshire, R.J.E., 2001: Historical taxonomy and a resolution of the *Stylidium graminifolium* complex (Stylidiaceae) in Tasmania. *Australian Systematic Botany* 14: 937–969.

Macphail, M.K. & Jackson, W.D., 1978: The Late Pleistocene and Holocene history of the Midlands of Tasmania, Australia: Pollen evidence from Lake Tiberias. *Proceedings of the Royal Society of Victoria* 90: 287–300.

Macphail, M.K., Shepherd, R.R., Brown, M.J. & Jackson, W.D., 1975: *Norfolk Range Area Environment Statement.* Tasventure Environment Centre, Devonport.

Potts, B. M. & Jackson, W. D., 1986: Evolutionary processes in the Tasmanian high altitude eucalypts. *In* Barlow, B.A. (Ed.): *Flora and Fauna of Alpine Australasia. Ages and Origins.* CSIRO, Melbourne: 511–527.

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TASMANIA'S EUCALYPTS: THEIR PLACE IN SCIENCE

by Brad M. Potts and James B. Reid

(with four text-figures and 13 plates)

POTTS, B.M. & REID, J.B., 2003 (19:xii): Tasmania's eucalypts: their place in science. *Papers and Proceedings of the Royal Society of Tasmania* 137: 21-37. ISSN 0080-4703. School of Plant Science and CRC for Sustainable Production Forestry, University of Tasmania, Private Bag 55, Hobart, Tasmania 7001, Australia. (BMP*, JBR) *Author for correspondence.

While representing only 29 of the more than 700 eucalypt species, those on the island of Tasmania have a unique place in the history and scientific discovery of this iconic genus. Eucalypts entered written history when Abel Tasman discovered Tasmania in 1642 and the type specimen for the genus, *Eucalyptus obliqua* L'Hér., was collected from Bruny Island in 1777 during Cook's third voyage. The discovery of some of the endemic taxa was linked with the French expedition searching for La Pérouse in 1792–1793, and the return of the type specimens to France was a great triumph against adversity. Nearly half a century later British botanists contributed to the discovery of the Tasmanian eucalypts with colonial collectors sending specimens to Kew Gardens, and with Australian-based botanists completing the pioneering stages of botanical discovery in the early 1900s. Botanists in Tasmania then led experimental approaches to understanding their evolution, ensuring a place for the island's eucalypts in twentieth-century science. The first major study of eucalypt chromosomes and cell division was undertaken with the Tasmanian eucalypts in the 1930s. The post-war decade saw the establishment of many of the lines of scientific enquiry pursued today, through the research of pioneering Tasmanian scientists such as H. Newton Barber and the recently deceased Bill Jackson, both of whom served as Professor of Botany at the University of Tasmania. Their studies of the roles of natural selection and hybridisation in the evolution of tree genera led to outstanding work on the nature and origins of clinal variation. Molecular techniques have now allowed many of the questions posed by the early work of Jackson and Barber to be addressed. However, just as old questions are answered, new questions arise as genomic studies on this unique Australian genus open a new era of scientific discovery.
Key Words: *Eucalyptus*, Tasmania, history, chromosomes, natural selection, hybridisation, clinal variation, quantitative genetics, molecular genetics.

INTRODUCTION

Eucalypts, in the broad sense, include species from the genera *Angophora, Corymbia* and *Eucalyptus* (see Ladiges & Udovicic 2000, Steane *et al.* 2002) and are native only to Australia and islands to its immediate north (Eldridge *et al.* 1993). They are a dominant component of Australia's forests and woodlands, and are critically important to biodiversity (Williams & Woinarski 1997) and commercial forestry (Eldridge *et al.* 1993, Turnbull 1999). Eucalypts are also Australia's major germplasm contribution to the world and are now the most-planted hardwood trees globally, with over 12 million hectares of plantation established (Turnbull 1999). Only 29 of the more than 700 species of eucalypts currently recognised are native to the island of Tasmania (Williams & Potts 1996) and only two of the 13 major evolutionary lineages recognised by Brooker (2000) are present. Tasmania, therefore, has neither the great taxonomic diversity of Queensland (Ladiges 1997) nor the floral diversity seen in Western Australia with the large red flowering species such as *Corymbia ficifolia* or *Eucalyptus macrocarpa* (Brooker & Kleinig 1990). However, the island does have a group of species that have a unique place in the history and the scientific discovery of this typically Australian genus. Work by numerous scientists has given them a status within botanical, evolutionary and forestry research, far in excess of the number of species present on the island. The Tasmanian eucalypts have, for example, provided numerous insights into the evolution of trees (e.g., Barber & Jackson 1957, Jackson 1960a, Potts & Jackson 1986, Potts & Reid 1988, McKinnon *et al.* 2001a). This paper is an account of the scientific discovery of these species and is a tribute to the contributions of the recently deceased Professor Bill Jackson and his predecessor Professor Newton Barber, who together initiated many of the current directions of research aimed at understanding eucalypt biodiversity and evolution in Tasmania.

DISCOVERY OF THE GENUS 1642–1788

The Tasmanian eucalypts were the first eucalypts clearly to be recorded by Europeans. It is possible that Portuguese (McIntyre 1977, Wallis 1988) or Dutch (e.g., voyage of the ships *Pera* and *Arnhem* in 1623, Schilder 1988) traders/explorers encountered eucalypts on the islands to the north of Australia, or even on continental Australia, in the sixteenth or early seventeenth century. However, the first written record appears to be from Abel Tasman's discovery of what he named Van Diemen's Land in 1642 (Zacharin 1978, Doughty 2000, Hay 2002) when he was in search of new trading lands and a shorter trade route to Chile for the Dutch East India Company. Brief landings were made while Tasman's ships, the *Zeehaen* and *Heemskerck*, were anchored in the lee of Visscher Island, off Cape Fredrick Henry on the northern end of Forestier Peninsula (pl. 1), between 1 and 4 December (Julian calendar) (Somerville 1964, Taylor 1973, Duyker 1992, Hay 2002).

The first European landing on Tasmanian soil was made on 2 December when Blackman Bay was charted. While the exact site of the first landing is not clearly recorded, Curtis & Somerville (1948) argue that from the vegetation descriptions and collections, they probably landed at Boomer Creek on the western shore of Blackman Bay (pl. 2) at least sometime during the day. This is three kilometres from where the monument marking the landing is erected. The shore party, led by the commander of the *Zeehaen*, Pilot-major Francoys Visscher, noted the abundance of excellent timber, with several trees 60–65 feet to the lowest branches, and

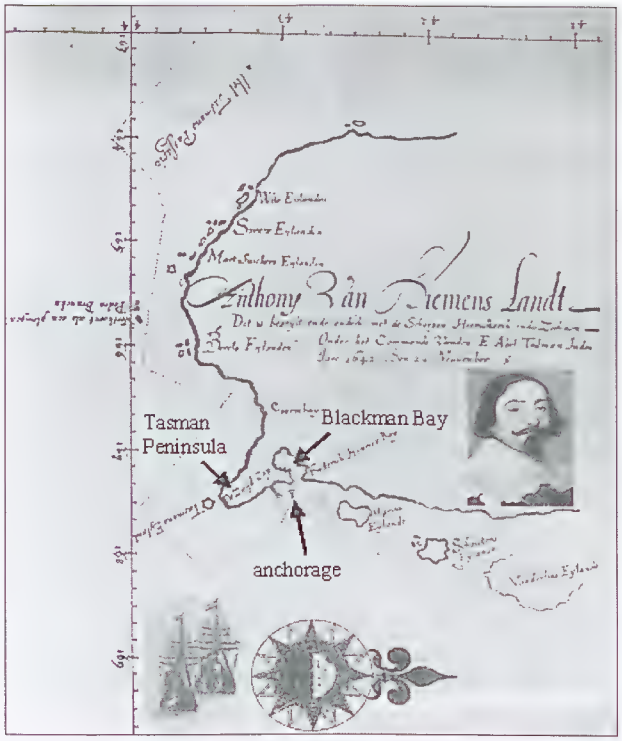

PLATE 1

Abel Tasman's chart showing the expedition's anchoring position in 1642 that is ENE of Tasman Bay on the Forestier Peninsula in the lee of Visscher Island. The nearby bay charted by the first landing party and labelled Frederick Hendricx Bay is the present day Blackman Bay where the first European landing on Tasmania and first recorded encounter of eucalypt trees occurred (from Duyker 1992). The inserts show the bust of Abel Tasman and the ships Zeehaen *and* Heemskerck.

PLATE 2

Boomer Creek, in Blackman Bay, the site at which Abel Tasman's landing party is believed to have collected water and edible herbs from the salt marsh on 2 December 1642 (Curtis & Somerville 1948). This is likely to have been the site from where the first recorded observations of eucalypt trees were made. The trees on the left are Eucalyptus globulus*;* E. ovata *grows near the creek and the forest on the hillside is comprised of* E. globulus, E. amygdalina, E. obliqua *and* E. viminalis.

PLATE 3

Tasman Bay on Forestier Peninsula where Abel Tasman's carpenter, Pieter Jacobsz, swam ashore and planted a flag on 3 December 1642. The arrow shows the site of the monument marking the landing. A shallow reef shelters the bay and rough seas on the day prevented the long boat landing. The prominent tall trees along the entire foreshore in this general area are Eucalyptus globulus *and from Tasman's description there is little doubt that the flag was placed in front of a tree of this species. The only other eucalypts at Tasman Bay today are small trees of* E. obliqua *and the occasional* E. tenuiramis.

brought back some fine gum that had dripped from the trees and resembled gum-lac (resin exuded by various trees and used in the manufacture of lacquer) (Walker 1891, Somerville 1964, Zacharin 1978, Duyker 1992). Zacharin (1978) considers their description almost certainly refers to *Eucalyptus globulus* Labill. (pl. 2). The landing party reported notches cut into the trees for climbing that were fully five feet apart, leading to the belief that the inhabitants of the island were very tall. They also reported animal tracks not unlike those of the tiger's claws on the ground beneath the trees.

The landing party was watching for attack from natives and commented upon the open nature of vegetation that allowed good visibility. This is consistent with the remnants of the dry, open forest of *E. globulus, E. pulchella* Desf., *E. amygdalina* Labill., *E. ovata* Labill. and *E. viminalis* Labill. that occur around the shores of Blackman Bay today. The following day the ship's carpenter swam through high seas to place a pole with the Company's mark and their Prince's flag in the middle of the Tasman Bay shore (pl. 3) and claimed the land as rightfully theirs (Duyker 1992: 15). The flag was planted "... near four high recognizable trees in the shape of a half-moon" which were no doubt *E. globulus*. The only other species currently growing at this exact spot are *E. obliqua* and the occasional *E. tenuiramis* Miq. (Peninsula form), but these are low trees and it is only *E. globulus* that stands out as a prominent tree.

While eucalypts had been collected from the east coast of mainland Australia during Captain James Cook's first voyage to Australia in 1770 (Hay 2002), the first eucalypt to be formally described was from Tasmania (L'Héritier de Brutelle 1788). It was a specimen of *E. obliqua* L'Hér. (pl. 4), collected from Adventure Bay on Bruny Island, and is the type specimen for the genus (Kantvilas 1996). The specimen was collected by William Anderson and his assistant David Nelson when Cook's two ships anchored at Adventure Bay from 26 to 30 January 1777 (Cook's ill-fated third voyage). Anderson, a surgeon, was the botanist and naturalist on the *Resolution* and had accompanied Cook on his previous voyage to the Pacific. He was interested in

PLATE 4

The type specimen of the genus Eucalyptus *was described by Charles L'Héritier de Brutelle in 1788 from a specimen of* E. obliqua *collected on 26–30 January 1777 from Adventure Bay, Tasmania during Captain James Cook's third voyage to Australia. The drawing accompanying the description is by a famous botanical artist of the day, Pierre-Joseph Redouté. This work pre-dates by 16 years the 1804 drawing of* E. obliqua *which Zacharin (1978) gives as the first known drawing of a eucalypt.*

fragrant plants and was probably the first person to make detailed observations on the eucalypts, recording the possible presence of two species at Adventure Bay (Hay 2002). He died in the Behring Strait in 1778 and it was Nelson, the gardener and collector on the *Discovery*, who then became responsible for the plants and the return of the collections. Nelson was based at Kew Gardens in England and was sponsored by Sir Joseph Banks who was by then director of Kew Gardens, the world's key botanical centre at the time. The eucalypt specimens from this voyage were lodged at Kew Gardens but, along with specimens of previous voyages, remained undescribed for nearly a decade (see Hay 2002). It was the French botanist Charles L'Héritier de Brutelle who finally described one of these specimens in 1788. L'Héritier, a magistrate by profession and an aristocratic supporter of the concept of the French Revolution, was a self-taught botanist with a particular interest in trees (Hay 2002). It was during his visit to London in 1786–87 that he worked on the extensive herbarium held by Banks and recognised the new genus with a name having a Greek root reflecting the unique cup-like operculum covering the flower (*eu* — well and *calyptos* — covered). L'Héritier was mysteriously murdered one night in the streets of Paris in 1800 (Zacharin 1978, Hall 1979).

Tasmanian seed of *E. obliqua* also appears to have produced the first eucalypt specimens to be grown in cultivation outside Australia (Somerville 1964, Doughty 2000). The seed was collected when the second ship of Cook's 1772 expedition, *Adventure*, under the command of Captain Tobias Furneaux, briefly landed at Bruny Island in March 1773 while en route to New Zealand. The head gardener at Kew seems to have planted seed after their return in July 1774 and a live specimen of *E. obliqua* was recorded to be growing at Kew in 1789.

THE FRENCH CONNECTION 1791–1806

French botanists played an important role in the initial discovery of the Tasmanian eucalypt flora, providing the first major collections and descriptions of the Tasmanian eucalypt species (Kantvilas 1996). These early samples of eucalypts have a special place in science history because of their association with key events in world history (see Horner 1995, Duyker & Duyker 2001, Duyker 2003). They were part of the plant collection of the French botanist, Jacques Julien de Labillardière (pl. 5), made during the Bruny D'Entrecasteaux expedition in the ships, *Recherche* and *Espérance* (Labillardière 1800). The expedition visited Tasmania in both 1792 and again in 1793 and explored extensively the D'Entrecasteaux Channel region from anchorages at Recherche Bay (Pigsties Bay and Rocky Bay respectively). The French explorers were overwhelmed by the tall eucalypt forests of southern Tasmania (Labillardière 1800; Duyker & Duyker 2001), with D'Entrecasteaux noting on his arrival in 1792:

> ... "It will be difficult for me to describe my feelings at the sight of this solitary harbour situated at the extremities of the world, so perfectly enclosed that one feels separated from the rest of the universe. Everything is influenced by the wilderness of the rugged landscape. With each step, one encounters the beauties of unspoilt nature, with signs of decrepitude; trees reaching a very great height, and of corresponding diameter are devoid of branches along the trunk, but crowned with an everlasting green foliage. Some of these trees seem as ancient as the world, and are so tightly interlaced that they are impenetrable. They support other trees of equal measurements which fall from old age, and nourish the soil with their decaying fragments. Nature, in all its vigour, and at the same time in decline, offers to the imagination something more imposing and picturesque than the sight of this same nature embellished by civilized man's industry. In wishing to conserve only its beauty, man has managed to destroy its charm and ruin its exclusive character — the one of being always old, and always new." (Duyker & Duyker 2001: 32; see also Horner 1995: 69).

Labillardière appears to have collected *E. cordata* Labill., *E. globulus* Labill., *E. ovata* Labill., *E. viminalis* Labill.,

PLATE 5

The French naturalist Jacques-Julien Houtou de la Billardière (who signed as Labillardière) described five of the six eucalypt species he collected when the D'Entrecastaux expedition visited Tasmania in 1792 and 1793 (Labillardière 1800). The lithograph was produced by Julien L. Boilly, 1821 (Zacharin 1978).

E. amygdalina Labill. and *E. pulchella* Desf. during these two visits together with numerous other Tasmanian plant species (Duyker 2003). He also recorded some of the earliest encounters of Europeans with the Tasmanian Aborigines.

The D'Entrecasteaux expedition was undertaken in the middle of the French Revolution to search for the lost expedition of La Pérouse (see Horner 1995). It was a mercy mission, but ended up with a mini-revolution on board the ships with a major split between the royalist officers and the republican crew and many of the scientists, including Labillardière. After unsuccessfully scouring the Pacific for La Pérouse and the death of many of the crew, including D'Entrecasteaux, the ships were desperately in need of replenishments and repair. The expedition was forced to stop at the Dutch settlement of Surabaya on Java. The Dutch by this stage were at war with the revolutionary government in France and, at the request of royalist officers who remained faithful to the French Monarchy, the Dutch authorities jailed the republican crew and scientists. The expedition was forced to stay at Surabaya and eventually it became necessary for the royalist officers to sell the ships to the Dutch in repayment for the debts incurred by the expedition. The expedition's papers and natural history collections, including Labillardière's plant collection and the Tasmanian eucalypt specimens, were sent back to Europe with a convoy of Dutch merchant ships in 1795 accompanied by royalist members of the expedition. By this time, the French, under Napoleon Bonaparte, had conquered Holland so the English intercepted the convoy of its former ally at St Helena to prevent its merchandise falling into the hands of the French Republicans. The English transferred the papers and natural history collections from the D'Entrecasteaux expedition to an English warship for safe keeping for the "legitimate" king of France, Louis XVIII, who England still recognised. As it eventuated, this transfer was fortunate as the Dutch merchant ship originally carrying the expeditions crates subsequently sank in a squall.

Labillardière was eventually released from imprisonment in Java and returned to France in 1796 to write the first widely read account of the D'Entrecasteaux expedition, which was the republican version of events (Labillardière 1800). He also set about getting back his collection which, in the meantime, had been offered to Queen Charlotte, the Queen of England, by Louis XVIII and was being held by Sir Joseph Banks. While France and England were still at war, Labillardière did get his specimens, by what appears to be a ruse to which Banks was complicit, claiming that he (Labillardière) had received no salary whilst on the expedition and that the specimens were his rightful property not that of Louis XVIII (Horner 1995). The correspondence of Banks and Labillardière over this period is now famous for demonstrating how science can overcome the barriers of bureaucracy and politics (De Beer 1960).

On return of the specimens, Banks wrote:

> ..."I confess I wished much to learn from his specimens some of those discoveries in the natural order of plants which he must have made, but it seemed to my feelings dishonourable to avail myself even of the opportunity I had of examining them: I of course did not look them over: all will be returned to him. I shall not retain a leaf, a flower, or a Botanical idea of his Collection, for I have not possessed myself of any thing at all of his, that fortune committed to my custody" (to Antoine-Laurent de Jussieu, De Beer 1960: 65).

The return of the collection allowed Labillardière to produce the first publication covering the flora of Australia, issued in parts between 1804 and 1807 (Labillardière 1804–1807). As the collection from the D'Entrecasteaux expedition was considered part of Labillardière's private herbarium, it was sold to a private collector on his death in 1834. It was subsequently bequeathed to the Grand Duke of Tuscany and is now held at the Museo Botanico at the University of Florence in Italy (Duyker 2003).

Labillardière described the Tasmanian eucalypts he collected in either 1799 (*E. globulus* – Labillardière 1800 – French version 1799) or 1806 (*E. amygdalina, E. cordata, E. ovata, E. viminalis* – Labillardière 1804–1807). There is some confusion in the literature as to the exact location from which some of these specimens were collected (e.g., *E. ovata*). He appears to have accessed some plant specimens collected by Leschenault de la Tour, the botanist on the Baudin expedition to Australia and Tasmania in 1800–1804, which were assimilated into his private herbarium (Kantvilas 1996). However, Labillardière (1800) recorded collecting several species of eucalypts to the northeast of their anchorage at Recherche Bay (in Pigsties Bay) on 23 April 1792 (*E. amygdalina, E. globulus, E. nitida, E. obliqua, E. ovata* and *E. tenuiramis* occur in this general area; Williams &

Potts 1996). Recherche Bay is clearly the type locality of *E. globulus* (Tasmanian Bluegum), as Labillardière specifically recorded collecting *E. globulus* on 6 May 1792 by felling a tree in order to obtain flowers (which is strange as the species normally flowers between September and December; Williams & Potts 1996), and designated the name for the species in his journal (Labillardière 1800). He was enthusiastic about the uses of the timber of the huge eucalypts observed at Recherche Bay and recorded that the carpenters had used planks of *E. globulus* to raise the gunwales of the ship's launch. While *E. cordata* was thought for many years to have been collected also from Recherche Bay, Labillardière (1800) specifically recorded collecting it from Penguin Island while the expedition was anchored in Adventure Bay, just prior to their departure from Tasmania in February 1793. The occurrence of a small population of *E. cordata* on this tiny island subsequently escaped the attention of naturalists until 1987 due to the inaccurate citation of the type locality in early taxonomic literature (see Potts 1988). Labillardière's clear account of its collection on the island and the small size of the extant population suggests that the type locality for this species may be one of the most accurately known for this period of botanical exploration in Australia (Potts 1988).

THE FEVER TREE 1804 ONWARDS

The Tasmanian floral emblem, *E. globulus*, was among the first eucalypts to be formally described. Following its discovery, it was rapidly spread throughout the world and it is the species by which most of the world first knew the genus *Eucalyptus* (Jacobs 1981, Doughty 2000, Lopez *et al.* 2001). There are now over 1.3 million hectares of *E. globulus* planted outside Australia (Doughty 2000) and about 0.4 million hectares of plantations established in Australia (Wood *et al.* 2001). It is the most important plantation eucalypt in temperate regions of the world where it is grown mainly for pulpwood production (Eldridge *et al.* 1993).

The primeval eucalypt forests of Tasmania were among the tallest forests in the world (Lewin 1906, pl. 6). *Eucalyptus globulus* was one of the tallest species observed, with huge trees up to 96 m (318 feet) in height recorded (Irby 1925; see also Hickey *et al.* 2000, Appendix 2). The proximity of native *E. globulus* to the coast ensured rapid use and knowledge of its timber by the early explorers and colonists (Lewin 1905, 1906, Kostoglou 1994a, b, 1995). The extensive waterways and sheltered harbours of southern Tasmania meant shipping facilities were ideal for transport of timber from these tall coastal forests at minimal cost. Huge logs of this species were transported to England where they were exhibited at The Great Exhibition of 1851 attracting great interest (Doughty 2000). The high-density timber was durable and resistant to the destructive Teredo sea-worm and *E. globulus* became prized for marine construction (Lewin 1905, 1906). By the late 1800s, giant trees 60–90 m high were regularly harvested from the forests of Tasman Peninsula, Bruny Island and the borders of the D'Entreacasteaux Channel and shipped throughout the world for wharf piles (100–120 feet in length and 20 inches square; 30–37 m by 0.5 m square).

By 1905, four million feet of piles had been supplied for British Admiralty contracts, including the naval docks at Dover (Lewin 1905). These huge *E. globulus* piles were acknowledged as "... the longest and biggest and the most durable that had ever reached British shores" (Lewin 1906: 38). The strong durable timber was in demand for railway sleepers, street paving blocks and mining purposes. The Tasmanian eucalypts, *E. globulus* and *E. obliqua*, were a favourite with miners as they could bear great loads, and would not snap suddenly, but bend and always give warning before giving way (Lewin 1906). Even in warfare *E. globulus* proved superior with tests showing cannon balls would pierce, but not splinter its planks (Lewin 1906). By 1925, the Conservator of Forests, L. G. Irby (1925: 235), notes of the coastal forests around the southern Tasmanian waterways that "... sawmilling, splitting, felling, burning off, together with devastating bush fires, have all been taking heavy toll for a century past... Of the valuable timber species ... the Blue-gum is the only species at all scarce; regrowth of this species exists in many parts, but of mature trees the supply is now very low."

PLATE 6

The 'Big Ben' eucalypt tree at Port Esperence, southern Tasmania. Its height was nearly 250 feet (76 m); circumference (5 feet {1.5 m} from ground level) was 95 feet (29m) and the interior of the hollow measured 20 feet x 25 feet (6 m x 7.8 m) (from Lewin 1906).

The spread of *E. globulus* plantations around the world was aided, not only by a great interest in the species as a timber tree, but also by the unpalatability of its juvenile foliage to cattle, sheep and goats (Jacobs 1981). There was also the unsubstantiated belief that, along with other eucalypts, it had properties that could result in the banishment of diseases such as malaria (Doughty 2000). *E. globulus* became known as the 'fever tree' (Lewin 1905), and in the latter half of the nineteenth century, millions of trees were planted to combat malaria in countries such as Algeria (Lewin 1906, Zacharin 1978). Such remedial effects of eucalypts were

believed to be due to improved drainage through the fast growth as well as pharmacological properties of the bark and foliage. Scientific debate on this topic raged through the latter half of the nineteenth century, with *E. globulus* a central species in the debate. Simultaneously, cultivation of *E. globulus* specifically for timber and fuel production was rapidly expanding in many parts of the world. Its spread into California, for example, occurred at the time of the gold rush with it being widely promoted by government agencies and private investors as a source of construction timber and fuel wood (Doughty 2000). However, by the beginning of the twentieth century warping and splitting problems in the exotic-grown timber greatly reduced interest in its use for construction. Nevertheless, younger trees were still of interest as mine props and this was one of the main reasons for its early planting in Chile, near Lota.

Much *E. globulus* seed was distributed directly from Australia by, for example, Ferdinand von Mueller, the director of the Royal Botanical Gardens, Melbourne, who considered *E. globulus* the 'Prince of Eucalypts' (Doughty 2000: 51). France is believed to have been a key secondary distribution point (Zacharin 1978). *E. globulus* appears to have been initially grown in France from seed brought back from the Baudin expedition in 1804 (Horner 1995) and the species has been cultivated near major Mediterranean ports such as Toulon since 1813 (Doughty 2000). Indeed, Labillardière had strongly advocated the introduction into the south of France of several Australian species he had collected, including the mighty blue gum, and this was the subject of his last surviving letter, written in a trembling hand to the vice-president of the French Academie des Sciences in 1833 (Duyker 2003).

PLATE 7
The Kew-based botanist, Sir Joseph Dalton Hooker, who described five of the Tasmanian endemic eucalypts <http://www.rbgkew.org.uk/aboutus/jhooker.html>. *(Reprinted with the permission of the Trustees of the Royal Botanic Gardens, Kew).*

TREES FROM THE COLONIES 1840–1860

While eucalypts were rapidly introduced into the British Isles and the Tasmanian species had the reputation as the more frost-resilient (Zacharin 1978, Doughty 2000), it was not until nearly 50 years after the genus was discovered that English botanists described any of the Tasmanian eucalypt flora (Hall 1979, Kantvilas 1996). Five Tasmanian endemics — *E. coccifera* Hook. f., *E. gunnii* Hook. f., *E. nitida* Hook. f., *E. urnigera* Hook. f. and *E. vernicosa* Hook. f. — were described by Sir Joseph Dalton Hooker (pl. 7) who replaced his father, Sir William Jackson Hooker, as director of Kew Gardens in 1865. The endemics he described were mainly collected by Tasmanian-based collectors whom he had recruited, in particular Ronald Gunn and Robert Lawrence (Burns & Skemp 1961, Kantvilas 1996). However, Hooker spent nearly six months in Tasmania in 1840 and 1841 as part of his voyage to Antarctica. During this period, he specifically visited the central highlands to see the native habitat of the eucalypt from which Aborigines and stockmen collected and drank the often-fermented sap (Hooker 1845–1859, see also Potts *et al.* 2001). This species, known as the 'Cider tree', and subsequently described by Hooker as *E. gunnii*, is now recognised as one of the most frost-resistant of all eucalypt species (Potts & Potts 1986, Potts *et al.* 2001). At least in the Tasmanian context, this fact was evident early from Hooker's (1845–1859) description of the effects of the devastating frost of 1837:

> ... "(which) had killed all the other and larger species of Eucalyptus, especially on flat grounds, similar to, but at a lower elevation than those on which we were. For many miles on the road to the lakes, our course had been amongst the tall trunks of dead Gum trees... On the banks of Lake Echo, a beautiful sheet of water, a similar death-like scene met the eye. Gum trees, *Leptosperma*, *Hakeas*, and *Banksias*, all seemed as if they had been suddenly struck with some mortal disease in the full vigour of their growth, and in their prime of life. ...the effects of the great frost of 1837, ... proves at once how much hardier this species (*E. gunnii*) is, which, though growing at a much higher elevation, and on a marshy plain, where the effects of frost are always the most severe, was almost uninjured."

Because of its high frost resistance, extensive work has been undertaken on breeding *E. gunnii* in France (Potts & Potts 1986, Cauvin *et al.* 1987) and this work has shown populations around Great Lake on the Central Plateau are the most frost-resistant of the species (Cauvin & Potts 1987). The viability of these frost-resistant populations of *E. gunnii* on the Central Plateau are now threatened by extensive die-back which occurred in the 1990s due to a combination of drought and browsing (Potts *et al.* 2001).

TREES FROM THE ISLAND 1860–1937

By the early twentieth century more than 80% of the Tasmanian eucalypt species had been formally described (see Kantvilas 1996), with most of the later species being

described by mainland botanists working out of Melbourne (Mueller 1879–1884) or Sydney (Maiden 1903–1933; Barker & Smith 1912) (Hall 1979). These species included *E. regnans* F. v. M, *E. perriniana* F. v. M ex Rodway, *E. rubida* Deane & Maiden, *E. delegatensis* R.T. Baker, *E. rodwayi* Baker & Smith, *E. archeri* Maiden & Blakely, *E. dalrympleana* Maiden, *E. johnstonii* Maiden and *E. subcrenulata* Maiden & Blakely. Many of these species are non-endemic and were first described from mainland specimens. During this period botanists were still coming to terms with the exact constitution of the flora and the taxonomic priorities for naming (e.g., Rodway 1903, 1918, Maiden 1915, 1919, 1903–1933, Blakely 1934). For example, during this period *E. pulchella* was known as *E. linearis* Dehn., *E. delegatensis* as *E. gigantea* Hook. f., *E. nitida* Hook. f. as *E. simmondsii* Maiden, *E. sieberi* L.A.S. Johnson as *E. sieberiana* F. v. M., *E. rodwayi* as *E. aggregata* Deane & Maiden., *E. subcrenulata* as *E. muelleri* T.B. Moore and *E. amygdalina* as *E. salicifolia* Cav. There were also taxa recorded in Tasmania described from hybrid material (e.g., from Mt Nelson, *E. unialata* Baker & Smith {*E. viminalis* x *E. globulus* Maiden 1915}; from Alma Tier, *E. irbyi* Baker & Smith {*E. gunnii* x *E. dalrympleana* Pryor & Johnson 1971}; and from St Marys Pass, *E. taeniola* Baker & Smith {*E. amygdalina* x *E. sieberi* Jackson 1958}). In addition, there was incorrect assignment to mainland taxa that do not occur in Tasmania (e.g., *E. haemastoma* Sm.) or incorrect affinities recorded to Tasmanian taxa (e.g., the Tasmanian *E. perriniana* F. v. M. had been described as *E. gunnii* Hook. f. var: *glauca* Deane & Maiden). During this period, Baker & Smith (1920) undertook a major survey of the essential oils of the genus *Eucalyptus* and those of the Tasmanian species, collected by L.G. Irby, were completed in 1912 (Barker & Smith 1912). It was not until the 1990s that a similar task was repeated with modern analytical techniques (Li *et al.* 1995, 1996).

The early 1900s saw the end of the pioneering stages of botanical discovery that focused on collecting, describing and classification. The next stage of discovery of the Tasmanian eucalypts moved to a more detailed and experimental approach to understanding the relationships between species and their evolution.

TASMANIA'S INDEPENDENCE 1937

The new era of scientific discovery was led by Tasmanian-based scientists. Its starting point can be traced to the presentation of three key papers at the annual meeting of the Royal Society of Tasmania on 8 November 1937. The first major study of eucalypt chromosomes and cell division was presented by McAulay & Cruickshank (1938), expanding an earlier note in *Nature* (McAulay *et al.* 1936). This work was undertaken in the Physics Department at the University of Tasmania, where Alexander Leicester McAulay was the Professor. He was interested in the social and environmental applications of his discipline (Davis 1990) and had a great interest in the Tasmanian eucalypts. The chromosome studies required the most advanced optics available at the time and were undertaken with Fletcher Donaldson Cruickshank who was his second in charge and a specialist in optics. Interestingly, Cruickshank was a descendant of one of Tasmania's early explorers, Lieutenant John Hayes, who visited southern Tasmania two months after D'Entrecasteaux in 1793. Hayes' charting of this area and allocation of names such as Derwent River, Cornelian Bay, Risdon, Ralphs Bay (originally Relphs Bay) and Betsy Island, challenged the priority of the earlier French discoveries,

PLATE 8
Robert Gordon Lindsay Brett (far left) taken in 1939 outside the Hobart High School where he taught Science and Mathematics from 1918 to 1943 (from Batt 1963).

the reporting of which had been delayed by internment in Java as previously detailed (Lee 1912, Taylor 1973, Horner 1995). A cousin of Cruickshank's, Ernest Cruickshank, also played a key role in the Tasmanian Field Naturalists having *E. globulus* accepted as the floral emblem of Tasmania. The karyotype studies that McAulay and Cruickshank undertook heralded the University of Tasmania's long-running interest in eucalypt genetics that persists today, but in the School of Plant Science, not Physics.

At the same meeting, McAulay (1938) also presented a paper on the first experimental verification of natural hybridisation between two eucalypt species. Considerable debate had been held in scientific circles for decades as to whether eucalypt species hybridised in the wild (see Griffin *et al.* 1988). The first artificial hybrid had been produced by a nurseryman in Canberra (Maiden 1919) and Maiden had been arguing for some time that such hybrids did exist in the wild (Maiden 1904). However, it was McAulay who applied the genetic principles of progeny testing to give the first clear verification of their existence in the wild. The *E. ovata* x *globulus* hybrids he studied were found by Gordon Brett near Bagdad. Similar wild hybrids can be seen today at several sites on Mt Nelson and this hybrid combination has been produced artificially (Lopez *et al.* 2000).

The third key paper presented at this meeting was a major taxonomic review of the Tasmanian eucalypts by Gordon Brett (1938). This review was important as it challenged the concept of discrete biological species and recognised the large amount of variability and continuity within and between many of our described eucalypt species, a large part of which he believed to be due to hybridisation. Brett taught mathematics and science at Hobart High School (pl. 8) and had studied at the University of Tasmania under McAulay's father who was the Professor of Mathematics and Physics at the time. Brett went on to describe one of the rarest of all eucalypts, the Tasmanian endemic *E. morrisbyi* (Brett 1939). Brett almost completed another manuscript that was unfortunately lost to posterity in 1967, as in reflecting on Brett's life, Wilson (1975: 59) notes: "We recall the disastrous bush fires of 1967 when he lost his home, his professional library, most of his plants and other priceless treasures including the manuscript of his long awaited publication on eucalypts."

THE WAR EFFORT 1938–1950

While off to a good start in the 1930s, there was little publication of eucalypt research during the decade of the Second World War. During this period, the optical skills of McAulay and Cruickshank, for example, were focused on military work and an optical annex was established at the University of Tasmania where staff supervised 280 workers producing camera and gun sight components designed by Cruickshank (Davis 1990). However, some of the earliest work on artificial hybridisation of eucalypts was undertaken in Tasmania during and immediately after the Second World War. For example, *E. globulus* x *E. cordata* crosses were performed and almost certainly involved an *E. globulus* female (St Davids Park) crossed with *E. cordata* from Summerleas Road. Gordon Brett was involved in this work and Max Gilbert (pers. com. 1984) indicated that the progeny were planted at Taranna in 1945 and that he assessed them in 1954. Crossing possibly started in 1940 and other plantings were made in 1949. Interestingly, Tasmania was not the only place where eucalypts were being artificially hybridised during this war period. The largest program of artificial hybridisation of eucalypts at the time was being undertaken in Russia at a research station located near the Black Sea (Pilipenka 1969), but full details of this research were only revealed following translation of a review in the late 1980s (Griffin *et al.* 1988).

PATTERNS AND PROCESSES

The postwar decade saw many of the lines of enquiry clearly established that are pursued today. These research lines aimed to understand the evolutionary processes that have led to the patterns of variation and species inter-relationships seen in Tasmania. This work was initiated by the foundation Professor of Botany (1947–1964), Horace Newton Barber (Barber 1963, pl. 9), and was continued by William (Bill) Dalziel Jackson (pl. 10) who was one of his Ph.D. students and later became Professor of Botany (1966–1986). Barber was trained in genetics and cytology at Cambridge and was a Fellow of the Royal Society of London whereas Jackson commenced university studies during the uptake of ex-service personnel following the Second World War and undertook all his studies at the University of Tasmania. They published in the highest quality journals a series of landmark papers on continuous (termed clinal) variation in the Tasmanian eucalypts (Barber 1955, 1956, 1965, Barber & Jackson 1957). This work was backed by their increasing knowledge of eucalypt biology (Barber 1954, Jackson 1958) and ecology (Jackson 1965, 1968), and clearly placed Tasmanian eucalypts on the modern scientific map (e.g., Jones & Wilkins 1971, Endler 1977 & 1986, Frankham *et al.* 2002).

Natural Selection in Action

A key paper was published in the journal *Nature* (Barber & Jackson 1957) which described a steep cline in leaf glaucousness in *E. urnigera* on Mt Wellington, where at the lower altitudinal range the population is uniformly green while at the highest altitudes the population is uniformly glaucous due to a covering of extra-cuticular wax (fig. 1). This work was important, as Jackson (1960b) notes that at

PLATE 9

H. Newton Barber, Professor of Botany at the University of Tasmania between 1947 and 1964, initiated early studies of the processes leading to the evolution of the Tasmanian eucalypt flora (photo from School of Plant Science).

PLATE 10

Professor Bill Jackson (right) and Professor Lindsay D. Pryor in post-retirement discussion. There were two main research groups in Australia working on eucalypt genetics and evolution during the 1950s and early 1960s — one in Canberra with Pryor who was Professor of Botany at the Australian National University, the other in Tasmania where Professors Barber and Jackson were working. Professor Pryor focused on hybridisation during this period whereas the Tasmanian group was focusing on the role of natural selection in shaping variation patterns.

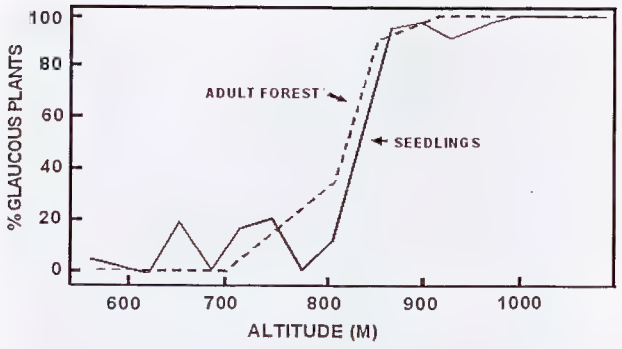

FIG. 1 — Clinal variation in the glaucousness of adult and juvenile foliage on Eucalyptus urnigera *with altitude on Mt Wellington, Tasmania. The adult trees were scored in the native forest whereas the seedlings were grown in the nursery from open-pollinated seed collected from the wild (redrawn from Barber & Jackson 1957).*

the time there was considerable controversy over the relative roles of genetic drift and natural selection in population differentiation (Wright 1948, Fisher & Ford 1950), and even many selectionists concurred with Haldane's (1959) views that natural selection occurred slowly and acted in a centripetal manner to restrict variation and evolutionary pathways. Many thought evolution operated through subtle differences in fitness. However, Barber & Jackson (1957) argued that there was nothing subtle about nature and that the changes in just one or two genes can mean the difference between life and death over very short geographical distances. Experimental evidence comparing phenotype frequencies in the adult and seedling cohorts supported the argument (Barber & Jackson 1957) and a subsequent progeny trial at Collinsvale clearly indicated that glaucous individuals from high altitudes could not survive at low altitude sites (fig. 2). The functional differences in phenotype observed along this cline were later examined by Thomas & Barber (1974a, 1974b) in one of the earliest attempts to provide a mechanistic explanation for such clines and the variation in fitness. Subsequent research identified partial barriers to gene flow along this cline arising from a stepped cline in flowering time (Savva *et al.* 1988).

Barber and Jackson's ideas were strongly influenced by the concurrent work of Max Gilbert, from the Forestry Commission who was studying the regeneration of *E. regnans* forest in the Florentine Valley after fire (Gilbert 1959, Barber 1965). At a current maximum height of 92 m recorded on a tree in the nearby Styx Valley, this species is currently the world's tallest flowering plant in natural forest (Hickey *et al.* 2000)[1]. His work showed that fierce density dependent selection must occur as the regenerating forest thins from over 100 000 seedlings per hectare after a fire to just a few per hectare (300 years post-fire), with only the very fittest surviving to contribute to the next generation. Intense selection against the products of inbreeding has subsequently been verified experimentally (Hardner & Potts 1997).

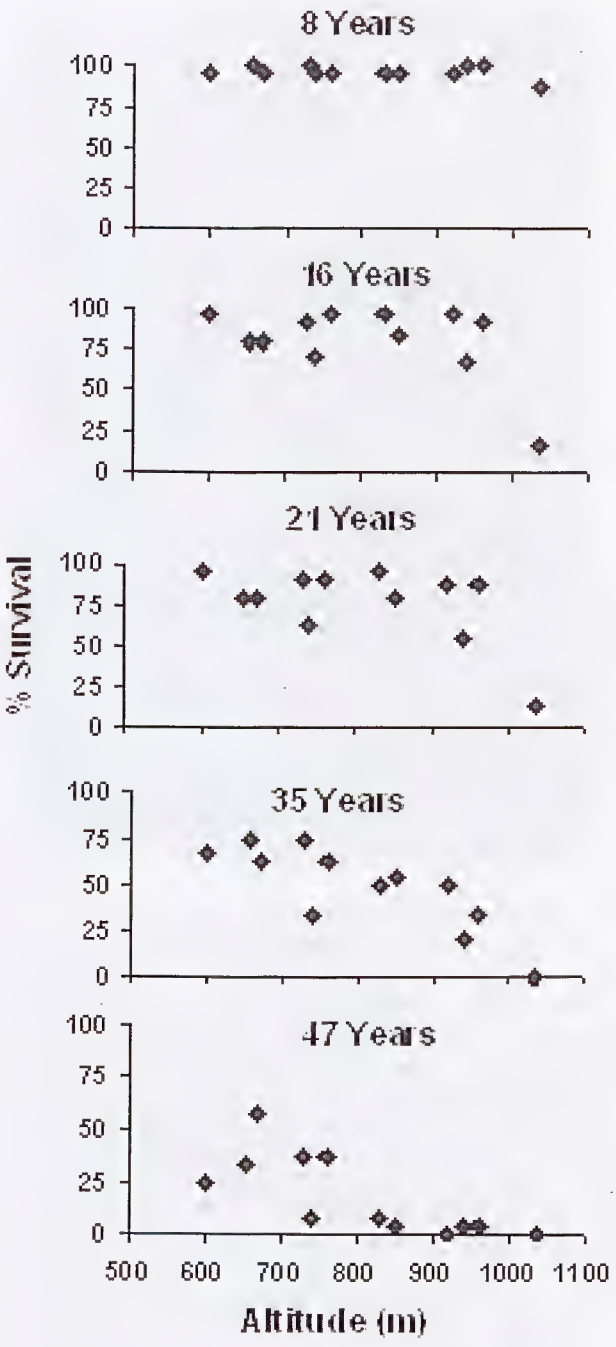

FIG. 2— Survival of open-pollinated progenies of Eucapytus urnigera *collected at a range of altitudes on Mt Wellington in an experimental field trial at Collinsvale (400 m). The data (8–35 years old) were collected by students of Botany at the University of Tasmania and the 47-year-old data by P. Tilyard. While there is clear selection against the glaucous, high altitudinal forms compared with the green, low-altitude forms at this low altitude site, this selection was not manifest in differential survival until at least 16 years after planting.*

[1] A recent laser-based measurement of a *E. regnans* tree in the Andromeda stand (the 'Mount' tree) has now given a tree height of 96 m (John Hickey pers. com. February 2003). The maximum height recorded for *E. regnans* in Tasmania is 99 m and for *E. globulus* 101 m (Hickey *et al.* 2000).

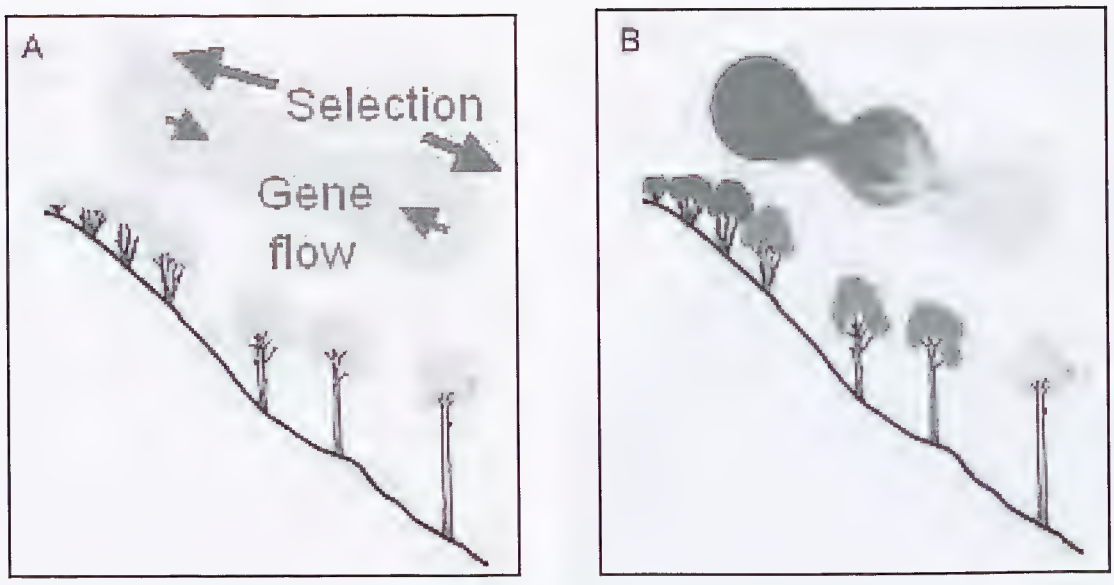

FIG. 3 — Hypotheses proposed to explain the origin of continuous variation in the Eucalyptus vernicosa *complex on mountains in Tasmania include (A) primary integration and (B) secondary intergradation. Primary intergradation would involve disruptive selection acting initially on a single gene pool with differentiation of extremes occurring* in situ *and countered by gene flow. Secondary integration would involve extreme morphs differentiating in isolation followed by subsequent contact, then hybridisation and introgression creating a continuum (from McGowen 2000).*

Clinal Variation in the Tasmanian Yellow Gums

Bill Jackson extended these studies of clinal variation from a single trait to the level of the whole plant phenotype in his Ph.D. studies on the Tasmanian Yellow gum complex (Jackson 1960a, 1960b). He showed that continuous variation exists between the three taxa from the unique shrub-like eucalypt *E. vernicosa* on mountain-tops, through *E. subcrenulata* to the tall trees with affinities to *E. johnstonii* in the sub-alpine forests. He attempted to deal with these multivariate clines but was hampered by the lack of computing power, instead being forced to use bivariate plots and ratios to display the multivariate phenotypic patterns. The genetic basis of these clines was demonstrated unequivocally through the development of common experimental gardens for seedlings derived from seed collected from different parts of the altitudinal range (pls 11–13).

The key question Bill Jackson was attempting to answer was how do these highly differentiated clines arise? He postulated two mechanisms (Jackson 1960b) to explain their origin:

(i) intense disruptive selection acting on a single population (fig. 3A), or
(ii) hybridisation between forms that have evolved in geographic isolation and subsequently come into contact (fig. 3B).

A major component of his work involved establishing a rigorous statistical approach to the quantification of this variation. In this respect he was strongly influenced by Sir Ronald Fisher (1930, 1936, 1937) who was the father of modern statistics and was based at the University of Adelaide during the late 1950s and interacted with the research group at the University of Tasmania during this period. This era founded Bill Jackson's long-standing interest in the application of statistics to biological problems and many students have fond memories of his long-running Biometry course.

QUANTITATIVE GENETICS

The line of statistical research established by Bill Jackson has led to the School of Plant Science at the University of Tasmania now having one of the largest research groups studying quantitative genetics of eucalypts. This work aims to use the phenotypic similarity between relatives in experimentally-designed trials of either open-pollinated or full-sib (known mother and father) progenies to estimate the extent to which traits are under genetic control. The application of this work to tree breeding involves using such experiments to predict which parents or offspring carry the most favourable genes or gene combinations. The scale of the experiments currently being undertaken and the technology for their analysis would be beyond the imagination of scientists of the 1960s and even 1970s. Many of the statistical and multivariate analyses that Bill Jackson was attempting were innovative and beyond the technology of the time. Calculations that were then taking months to do are now standard and can be done in seconds using high-speed computers.

Quantitative genetic studies of population variation in many of the Tasmanian eucalypt species have now been undertaken by students and staff at the University of Tasmania. Species studied include *E. dalrympleana* and *E. viminalis* (Phillips & Reid 1980), *E. coccifera* and *E. nitens* (Shaw *et al.* 1984), *E. gunnii* and *E. archeri* (Potts & Reid 1985a, 1985b), *E. perriniana* (Wiltshire & Reid 1987), *E. cordata* (Potts 1989), *E. risdonii* and *E. tenuiramis* (Wiltshire *et al.* 1991, 1992, 1998, Turner *et al.* 2001), and *E. barberi* (McEntee *et al.* 1994). However, it is the quantitative genetic work on *E. globulus* that has made this species one of the most intensively-studied forest tree species (reviewed in Dutkowski & Potts 1999, Raymond 2001, Lopez *et al.* 2002). Professor Jamie Kirkpatrick

PLATE 11

Eleven-year-old plants of (A) an alpine type intermediate between Eucalyptus subcrenulata *and* E. vernicosa *and (B) a forest type* E. johnstonii *at an arboretum at Stoodley in northern Tasmania (240 m altitude) (from Jackson 1960b).*

PLATE 12

Typical five-year-old seedling of Eucalyptus vernicosa *(left—Franklin Range 760 m),* E. subcrenulata *(right—Frankland Range 550 m) and* E. johnstonii *(Mt Wellington 730 m) grown in a common environment at Hobart demonstrate a genetic basis to variation in plant growth and form (from Jackson 1960b).*

PLATE 13

Typical leaves from parents (top) and progeny raised in a common environment at Hobart (bottom) showing a strong genetic basis to variation in leaf morphology between Eucalyptus vernicosa, E. subcrenulata *and* E. johnstonii *forms in Plate 12 (from Jackson 1960b).*

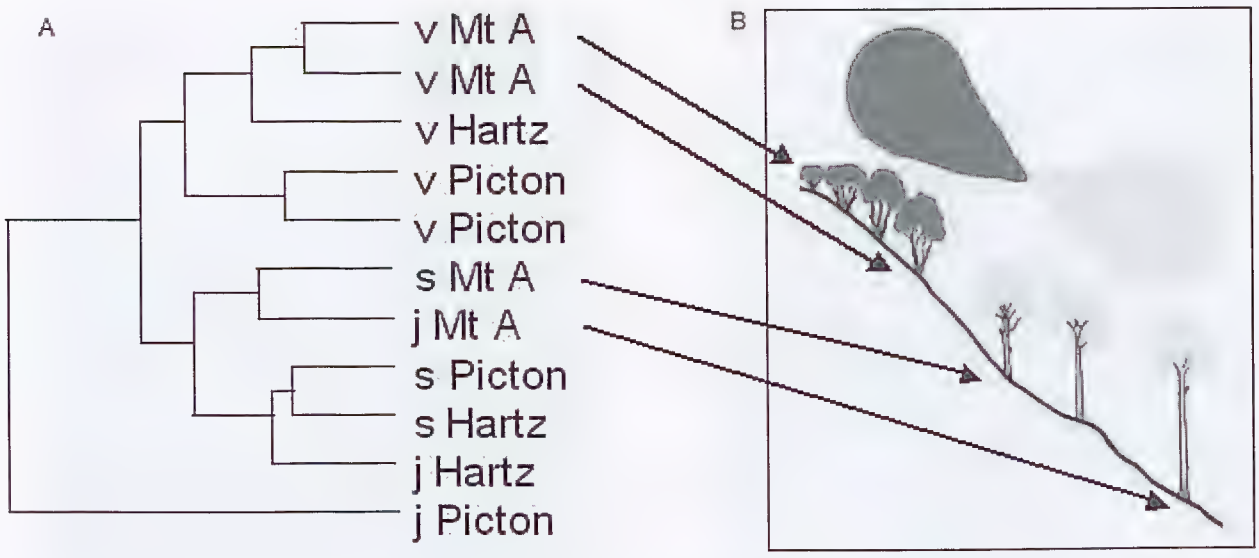

FIG. 4.— A dendogram showing molecular affinities of populations of the Eucalyptus vernicosa *complex (A) based on microsatellite markers which are believed to be neutral to selection (from McGowen* et al. *2001). Plants with affinities to* E. vernicosa *(v),* E. subcrenulata *(s) and* E. johnstonii *(j) trees were sampled along altitudinal gradients at three locations (Mt Arrowsmith, Mt Picton and the Hartz Mountains). The hypothesis explaining the origin of the continuum between* E. vernicosa *and tall forest forms resembling* E. johnstonii *in habit at the base of the mountain is shown in (B) (from McGowen 2000). In this case it is argued that in contrast to previous suggestions (fig. 3), the continuum is due to the convergence of two gene pools towards the same morph at intermediate altitudes (McGowen* et al. *2001).*

undertook the first major study of *E. globulus* during his Ph.D. studies at the University of Melbourne (Kirkpatrick 1975, see also Jordan *et al.* 1993). The patterns of diversity in the *E. globulus* gene pool have now been studied in large, range-wide collections of open-pollinated seed lots that have been distributed around the world for breeding purposes, starting over 25 years ago (Orme 1977, Borralho *et al.* 1992, Eldridge *et al.* 1993, Lopez *et al.* 2001). We now know the extent of genetic control of numerous traits including those affecting growth and survival, tree form, sexual reproduction, the timing of the distinctive heteroblastic change, characteristics of the juvenile leaf, coppicing and lignotuber development, bark and wood properties, and susceptibility to numerous pests. We know how genetic variation in the various traits is correlated, and how the expression of this variation changes with age and environment. We know how this genetic variation is distributed in native populations, not only on a broad geographic scale (Dutkowski & Potts 1999), but also within (Hardner *et al.* 1998) and between (Jordan *et al.* 2000) local populations. This detailed genetic knowledge is superimposed on a detailed understanding of breeding systems (e.g., Patterson *et al.* 2001, Pound *et al.* 2002), pollination ecology (Hingston 2002) and hybridisation potential (Gore *et al.* 1990, Potts *et al.* 2000, Volker 2002), Such knowledge, coupled with simple techniques now developed for controlled pollination (Williams *et al.* 1999), has made *E. globulus* a model tree species for genetic and evolutionary studies.

MOLECULAR GENETICS 1990 ONWARDS

A new era in our understanding of eucalypt genetics and evolution has come about through the revolution in molecular genetic technologies that has occurred over the past decade. Researchers in the School of Plant Science were the first to publish on DNA variation in eucalypts (Steane *et al.* 1991, Sale *et al.* 1993), and the stimulus for this work was the development of tools to study the evolution of the Tasmanian eucalypts. We can now monitor directly variation not only in the nuclear DNA (e.g., Steane *et al.* 2001, 2002), but also in the small maternally inherited DNA molecules in the chloroplast (Vaillancourt & Jackson 2000, McKinnon *et al.* 2001b) and mitochondria (R. E. Vaillancourt & A. Petty, unpubl. data) of eucalypt cells.

The development of this DNA technology has taken many years, but we are now at the stage where it can be applied on a large scale to address some of the questions Bill Jackson was asking decades ago. We have studied his Yellow gum cline and to our surprise the molecular data suggest that the continuum he observed is actually the result of the convergence of two separate gene pools (McGowen *et al.* 2001: fig. 4). DNA markers have revealed marked differentiation between populations of *E. globulus* (Nesbitt *et al.* 1995) with mainland populations morphologically classifying as the Tasmanian Blue gum, quite different from Tasmanian populations (Jones *et al.* 2002). Studies of the patterns of chloroplast variation in *E. globulus* and other Tasmanian species have provided evidence for past migration routes and glacial forest refugia (Freeman *et al.* 2001) and the sharing of the same chloroplast types by many species has provided evidence for ancient hybridisation amongst our species on a previously unimaginable scale (Steane *et al.* 1998, McKinnon *et al.* 1999, 2001a, in press).

THE FUTURE

The next decade will see major advances in our understanding of the eucalypt genome, due to research that is mainly driven by the worldwide commercial significance of eucalypts. The Tasmanian species have and will continue to play an important

role in this research. The first sequence of the important lignin gene CAD in trees was undertaken by French researchers working at the University of Toulouse with the Tasmanian endemic, *E. gunnii* (Feuillet *et al.* 1993, Grima Pettenati *et al.* 1993). This was also the first eucalypt-specific gene sequence published. Rudimentary maps of the genome of several eucalypt species have now been published. *E. globulus* is one of the species most intensively studied and maps of its genome have been published by Australian (Vaillancourt *et al.* 1994, Bundock *et al.* 2000, Thamarus *et al.* 2002) and overseas (Marques *et al.* 1998) research groups. Research is now focusing on identifying mutations, genes or genomic regions responsible for the variation in traits of economic significance including growth, propagation and wood quality traits (Marques *et al.* 1999, Moran *et al.* 2002, Thamarus *et al.* 2002, Poke *et al.* 2003) as well as hybrid inviability (Vaillancourt *et al.* 1994, Myburg *et al.* 2003). There are now several databases containing the sequences of many of the genes expressed in various tissues (e.g., cambium) of *Eucalyptus*, but these are not publicly available and are small compared to those available in crop species. Moves are already afoot to increase such sequencing efforts overseas (e.g., the GENOLYPTUS project in Brazil; Grattapaglia 2001) and there is growing interest in commencing large-scale sequencing of the eucalypt genome — just as has been done with the human genome.

While such genome studies with eucalypts can and are being done in many laboratories around the world, researchers at the University of Tasmania have a special niche. In addition to the technology, there is ready access to the natural ecosystem on an island with great diversity in environments and plant adaptation in which to apply these techniques. This is coupled with a long history of scientific exploration of eucalypt genetic diversity as well as clearly defined questions to answer thanks to the efforts of visionary botanists such as Newton Barber and Bill Jackson.

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REFERENCES

Baker, R. T. & Smith, H. G., 1912: A research on the eucalypts of Tasmania and their essential oils. *Papers and Proceedings of the Royal Society of Tasmania*: 139–209.

Baker, R. T. & Smith, H. G., 1920: *A research on the eucalypts especially in regard to their essential oils.* Sydney Government Printer, Sydney: 471 pp

Barber, H. N., 1954: A sterile eucalypt. *Papers and Proceedings of the Royal Society of Tasmania* 88: 285–287.

Barber, H. N., 1955: Adaptive gene substitutions in Tasmanian eucalypts: I. Genes controlling the development of glaucousness. *Evolution* 9: 1–15.

Barber, H. N., 1956: The natural history of natural selection. *The Australian Journal of Science*: 148–159.

Barber, H. N., 1963: *Botanist's Miscellany.* Reproduced privately by N. H. Rebrab, Printer under the Sign of the Dr. Syntax, Sandy Bay Rd., Hobart. 162 pp.

Barber, H. N., 1965: Selection in natural populations. *Heredity* 20: 551-572.

Barber, H. N. & Jackson, W. D., 1957: Natural selection in action in *Eucalyptus. Nature* 179: 1267–1269.

Batt, N., 1963: *Fifty years, 1913-1963: the history of the Hobart High School.* The School, Hobart. 96 pp.

Blakely, W. F., 1934: *A Key to the Eucalypts.* The Worker Trustees, Sydney: 339 pp.

Borralho, N. M. G., Cotterill, P. P. & Kanowski, P. J., 1992: Genetic parameters and gains expected from selection for dry weight in *Eucalyptus globulus* ssp. *globulus* in Portugal. *Forest Science* 38: 80–94.

Brett, R. G., 1938: A survey of the *Eucalyptus* species in Tasmania. *Papers and Proceedings of the Royal Society of Tasmania* 71: 75–109.

Brett, R. G., 1939: The description of a new eucalypt species. *Papers and Proceedings of the Royal Society of Tasmania* (1937): 129–130.

Brooker, M. I. H., 2000: A new classification of the genus *Eucalyptus* L'Hér. (Myrtaceae). *Australian Systematic Botany* 13: 79–148.

Brooker, M. I. H. & Kleinig, D. A., 1990: *Field guide to Eucalypts. Volume 2. South-western and southern Australia.* Inkata Press, Sydney: 428 pp.

Bundock, P. C., Hayden, M. & Vaillancourt, R. E., 2000: Linkage maps of *Eucalyptus globulus* using RAPD and microsatellite markers. *Silvae Genetica* 49: 223–232.

Burns, T. E. & Skemp, R. J., 1961: Van Dieman's Land Correspondents. *Records of the Queen Victoria Museum* 14: 1–142.

Cauvin, B. & Potts, B.M., 1991: Selection for extreme frost resistance in *Eucalyptus. In* Schönau, A.P.G. (Ed.): *Intensive Forestry: The Role of Eucalypts. Proceedings of the IUFRP symposium, P2.02-01. Productivity of Eucalypts, 2–6 September 1991, Durban South Africa.* Southern African Institute of Forestry, Durban: 209–220.

Cauvin, B., Potts, B.M. & Potts, W.C., 1987: *Eucalyptus*: hybridation artificielle – barrieres et hérédité des caracteres. *Annales de recherches sylvicoles* (Association Forêt-Cellulose: Paris) 1987: 255–303.

Curtis, W. M. & Somerville, J., 1948: Boomer Marsh - a preliminary botanical historical survey. *Proceedings of the Royal Society of Tasmania* 1947: 151–157.

Davis, R., 1990: *Open to talent: The centenary history of The University of Tasmania 1890–1990.* University of Tasmania, Hobart: 256 pp.

De Beer, G., 1960: *The sciences were never at war.* Nelson, London: 279 pp.

Doughty, R. W., 2000: *The* Eucalyptus. *A natural and commercial history of the gum tree.* The Johns Hopkins University Press, Baltimore and London: 237 pp.

Dutkowski, G. W. & Potts, B. M., 1999: Geographical patterns of genetic variation in *Eucalyptus globulus* ssp. *globulus* and a revised racial classification. *Australian Journal of Botany* 46: 237–263.

Duyker, E., 1992: *The discovery of Tasmania: Journal extracts from the expeditions of Abel Janszoon Tasman and Marc-Joseph Marion Dufresnen 1642 & 1772.* St David's Park Publishing, Hobart: 106 pp.

Duyker, E., 2003: *Citizen Labillardiére : a naturalist's life in revolution and exploration (1755–1834).* Miegunyah Press, Carlton: 383 pp.

DUYKER, E. & DUYKER, M., 2001: *Voyage to Australia and the Pacific 1791–1793.* Melbourne University Press, Melbourne. 392 pp.

ELDRIDGE, K., DAVIDSON, J., HARWOOD, C. & VAN WYK, G., 1993: *Eucalypt domestication and breeding.* Clarendon Press, Oxford: 288 pp.

ENDLER, J. A., 1977: *Geographical variation, speciation and clines.* Princeton University Press, Princeton: 246 pp.

ENDLER, J. A., 1986: *Natural selection in the wild.* Princeton University Press, Princeton: 336 pp.

FEUILLET, C., BOUDET, A. M. & GRIMA PETTENATI, J., 1993: Nucleotide sequence of a cDNA encoding cinnamyl alcohol dehydrogenase from *Eucalyptus. Plant Physiology* 103: 1447.

FISHER, R. A., 1930: *The genetic theory of natural selection.* Oxford University Press, Oxford: 272 pp.

FISHER, R. A., 1936: The measurement of selection intensity. *Proceedings of the Royal Society of London, Series B* 121: 58–62.

FISHER, R. A., 1937: The relationship between variability and abundance shown by the measurement of the eggs of British-nesting birds abundance. *Proceedings of the Royal Society of London, Series B* 122: 1–26.

FISHER, R. A. & FORD, E. B., 1950: The "Sewall Wright effect". *Heredity* 4: 117–119.

FREEMAN, J. S., JACKSON , H. D., STEANE, D. A., MCKINNON, G. E., DUTKOWSKI, G. W., POTTS, B. M. & VAILLANCOURT, R. E., 2001: Chloroplast DNA phylogeography of *Eucalyptus globulus. Australian Journal of Botany* 49: 831–835.

FRANKHAM, R., BALLOU, J. D. & BRISCOE, D. A., 2002: *Introduction to Conservation Genetics.* Cambridge University Press, Cambridge.

GILBERT, J. M., 1959: Forest succession in the Florentine Valley, Tasmania. *Papers and Proceedings of the Royal Society of Tasmania* 93: 129–151.

GORE, P. L., POTTS, B. M., VOLKER, P. W. & MEGALOS, J., 1990: Unilateral cross-incompatibility in *Eucalyptus*: the case of hybridisation between *E. globulus* and *E. nitens. Australian Journal of Botany* 38: 383–394.

GRATTAPAGLIA, D., 2001: Genomic technologies for the development of the eucalypt of the future. *In Developing the Eucalypt of the Future, Proceedings of IUFRO International Symposium, 10–15th September 2001.* Valdivia, Chile.

GRIFFIN, A. R., BURGESS, I. P. & WOLF, L., 1988: Patterns of natural and manipulated hybridisation in the genus *Eucalyptus* L'Hérit. — a review. *Australian Journal of Botany* 36: 41–66.

GRIMA PETTENATI, J., FEUILLET, C., GOFFNER, D., BORDERIES, G. & BOUDET, A. M., 1993: Molecular cloning and expression of a *Eucalyptus gunnii* cDNA clone encoding cinnamyl alcohol dehydrogenase. *Plant Molecular Biology* 21: 1085–1095.

HALDANE, J. B. S., 1959: The theory of natural selection today. *Nature* 183: 710–713.

HALL, N., 1979: *Botanists of the eucalypts.* CSIRO, Melbourne: 160 pp.

HARDNER, C. M. & POTTS, B. M., 1997: Post-dispersal selection under mixed-mating in *Eucalyptus regnans. Evolution* 51: 103–111.

HARDNER, C. M., POTTS, B. M. & GORE, P. L., 1998: The relationship between cross success and spatial proximity of *Eucalyptus globulus* ssp. *globulus* parents. *Evolution* 52: 614–618.

HAY, A., 2002: *Gum — The story of eucalypts and their champions.* Duffy & Snellgrove, Sydney: 275 pp.

HICKEY, J. E., KOSTOGLOU, P. & SARGISON, G. J., 2000: Tasmania's tallest trees. *Tasforests* 12: 105–105.

HINGSTON, A. B., 2002: Pollination Ecology of *Eucalyptus globulus* Labill. ssp. *globulus* and *E. nitens* (Deane & Maiden) Maiden (Myrtaceae). Unpublished PhD thesis. University of Tasmania, Hobart.

HOOKER, J. D., 1845-1859: *Botany of the Antarctic Voyage of H.M. Discovery Ships Erebus and Terror in the years 1939-1843.* Reeve, London. 3 vols, 6 parts.

HORNER, F., 1995: *Looking for La Pérouse.* Melbourne University Press, Melbourne: 318 pp.

IRBY, L. G., 1925: The Tasmanian forests. *Australian Forestry Journal* 8: 234–236.

JACKSON, W. D., 1958: Natural hybrids in eucalypts. Part I. *E.* X *taeniola* (= *E. salicifolia* x *E. sieberiana*). *Papers and Proceedings of the Royal Society of Tasmania* 92: 141–146.

JACKSON, W. D., 1960a: Clinal variation in *Eucalyptus vernicosa,* Part I. Taxonomic treatment. Unpublished Ph.D. thesis, University of Tasmania.

JACKSON, W. D., 1960b: Clinal variation in *Eucalyptus vernicosa,* Part II. The origin of clinal variation. Unpublished manuscript, University of Tasmania.

JACKSON, W. D., 1965: The Vegetation. *In* Davies, J. L. (Ed.): *Atlas of Tasmania.* Government Printer, Hobart: 30–35.

JACKSON, W. D., 1968: Fire, air, water and earth — an elemental ecology of Tasmania. *Proceedings of the Ecological Society of Australia* 3: 9–16.

JACOBS, M. R., 1981: *Eucalypts for Planting.* FAO, Rome:677 pp.

JONES, D. A. & WILKINS, D. A. R., 1971: *Variation and adaptation in plant species.* Heinemann Educational, London: 184 pp.

JONES, R. C., STEANE, D. A., POTTS, B. M. & VAILLANCOURT, R. E., 2002: Microsatellite and morphological analysis of *Eucalyptus globulus* populations. *Canadian Journal of Forest Research* 32: 59–66.

JORDAN, G. J., POTTS, B. M., CHALMERS, P. & WILTSHIRE, R. J. E., 2000: Quantitative genetic evidence that the timing of vegetative phase change in *Eucalyptus globulus* ssp *globulus* is an adaptive trait. *Australian Journal of Botany* 48: 561–567.

JORDAN, G. J., POTTS, B. M., KIRKPATRICK, J. B. & GARDINER, C., 1993: Variation in the *Eucalyptus globulus* complex revisited. *Australian Journal of Botany* 41: 763–785.

KANTVILAS, G., 1996: The discovery of Tasmanian eucalypts: an historical sketch. *Tasforests* 8: 1–14.

KIRKPATRICK, J. B., 1975: *Geographical Variation in* Eucalyptus globulus. Australian Government Publishing Service, Canberra: 64 pp.

KOSTOGLOU, P., 1994a: Historic timber-getting between Cockle Creek and Lune River Block 1. Archaeology of the Tasmanian Timber Industry Report No. 4. Tasmanian Forest Research Council, Inc, Hobart: 200 pp.

KOSTOGLOU, P., 1994b: Historic timber-getting between Hastings and Dover Block 2. Archaeology of the Tasmanian Timber Industry Report No. 5. Tasmanian Forest Research Council, Inc, Hobart: 190 pp.

KOSTOGLOU, P., 1995: Historic timber-getting on Bruny Island. Archaeology of the Tasmanian Timber Industry Report No. 7. Tasmanian Forest Research Council, Inc, Hobart: 108 pp.

LABILLARDIÈRE, J. J. D., 1800: Relation du Voyage à la Recherche de la Pérouse. H.J. Jansen, Paris. 2 vols and atlas.

LABILLARDIÈRE, J. J. D., 1804–07: Novae Hollandiae Plantarum Specimen. Dominae Huzard, Paris. 2 vols.

LADIGES, P. Y., 1997: Phylogenetic history and classification of eucalypts. *In* Williams J. & Woinarski J. (Eds): *Eucalypt Ecology: Individuals to Ecosystems.* Cambridge University Press, Cambridge.

LADIGES, P. Y. & UDOVICIC, F., 2000: Comment on a new classification of the eucalypts. *Australian Systematic Botany* 13: 149–152.

LEE, I., 1912: Commodore Sir John Hayes, his voyage and life. Longman, Green and Co., London: 340 pp.

LEWIN, D. W., 1905: *The Eucalypti hardwood timbers of Tasmania.* Gray Brothers, Hobart: 30 pp.

LEWIN, D. W., 1906: *The Eucalypti hardwood timbers of Tasmania* (2nd edition). Gray Brothers, Hobart: 138 pp.

L'HÉRITIER DE BRUTELLE, C. L., 1788: *Sertum Anglicum.* Facsimile edition 1963. Hunt Botanical Library, Pittsburg.

LI, H., MADDEN, J. L. & POTTS, B. M., 1995: Variation in volatile leaf oils of the Tasmanian *Eucalyptus* species. 1. Subgenus *Monocalyptus. Biochemical Systematics and Ecology* 23: 299–318.

LI, H., MADDEN, J. L. & POTTS, B. M., 1996: Variation in volatile leaf oils of the Tasmanian *Eucalyptus* species. II. Subgenus *Symphyomyrtus. Biochemical Systematics and Ecology* 24: 547–569.

LOPEZ, G., POTTS, B., DUTKOWSKI, G., APIOLAZA, L. & GELID, P., 2002: Genetic variation and inter-trait correlations in *Eucalyptus globulus* base population trials in Argentina. *Forest Genetics* 9: 223–237.

LOPEZ, G. A., POTTS, B. M., DUTKOWSKI, G. W. & RODRIGUEZ TRAVERSO, J. M., 2001: Quantitative genetic of *Eucalyptus globulus*: Affinities of land race and native stand localities. *Silvae Genetica* 50: 244–252.

LOPEZ, G. A., POTTS, B. M. & TILYARD, P. A., 2000: F_1 hybrid inviability in *Eucalyptus*: the case of *E. ovata* x *E. globulus. Heredity* 85: 242–250.

MAIDEN, J. H., 1903-1933: *A critical revision of the genus* Eucalyptus. Government Printer, Sydney. 8 vols.

MAIDEN, J. H., 1904: On hybridization in the genus *Eucalyptus. Australian Association for the Advancement of Science* 1904: 297–303.

MAIDEN, J. H., 1915: Notes on Tasmanian eucalypts. *Papers and Proceedings of the Royal Society of Tasmania* 1914: 20–31.

MAIDEN, J. H., 1919: Notes on Tasmanian eucalypts. *Papers and Proceedings of the Royal Society of Tasmania* 1918: 82–90.

MARQUES, C. M., ARAUJO, J. A., FERREIRA, J. G., WHETTEN, R., OMALLEY, D. M., LIU, B. H. & SEDEROFF, R., 1998: AFLP genetic maps of *Eucalyptus globulus* and *E. tereticornis. Theoretical and Applied Genetics* 96: 727–737.

MARQUES, C. M., VASQUEZ-KOOL, J., CAROCHA, V. J., FERREIRA, J. G., OMALLEY, D. M., LIU, B. H. & SEDEROFF, R., 1999: Genetic dissection of vegetative propagation traits in *Eucalyptus tereticornis* and *E. globulus. Theoretical and Applied Genetics* 99: 936–946.

MCAULAY, A. L., CRUICKSHANK, F. D. & BRETT, R. G., 1936: Chromosome number of *Eucalyptus globulus* and *Eucalyptus johnstoni. Nature* 138: 550.

MCAULAY, A. L., 1938: Evidence for the existence of a natural hybrid between *Eucalyptus globulus* and *Eucalyptus ovata. Papers and Proceedings of the Royal Society of Tasmania* 1937: 45–46.

MCAULAY, A. L., CRUICKSHANK F. D., 1938: The male meiotic cycle in the genus *Eucalyptus. Papers and Proceedings of the Royal Society of Tasmania* 1937: 41–44.

MCENTEE, A. C., POTTS, B. M. & REID, J. B., 1994: Variation in *Eucalyptus barberi* L. Johnson & Blaxell. *Papers and Proceedings of the Royal Society of Tasmania* 128: 21–30.

MCGOWEN, M. H., 2000: Clinal variation in the Yellow Gum complex. unpublished B.Sc. (Hons) thesis. School of Plant Science, University of Tasmania.

MCGOWEN, M. H., WILTSHIRE, R. J. E., POTTS, B. M. & VAILLANCOURT, R. E., 2001: The origin of *Eucalyptus vernicosa,* a unique shrub eucalypt. *Proceedings of the Royal Society of London* 74: 397–405.

MCINTYRE, K. G., 1977: *The secret discovery of Australia.* Souvenir Press Ltd, London. 427 pp.

MCKINNON, G. E., STEANE, D. A., POTTS, B. M. & VAILLANCOURT, R. E., 1999: Incongruence between chloroplast and species phylogenies in *Eucalyptus* subgenus *Monocalyptus. American Journal of Botany* 86: 1038–1046.

MCKINNON, G. E., VAILLANCOURT, R. E., JACKSON, H. D. & POTTS, B. M., 2001a: Chloroplast sharing in the Tasmanian eucalypts. *Evolution* 55: 703–711.

MCKINNON, G. E., VAILLANCOURT, R. E., TILYARD, P. A. & POTTS, B. M., 2001b: Maternal inheritance of the chloroplast genome in *Eucalyptus globulus* and interspecific hybrids. *Genome* 44: 831–835.

MCKINNON, G. E., JORDAN, G. J., VAILLANCOURT, R. E.; STEANE, D. A. & POTTS, B. M., in press: Glacial refugia and reticulate evolution: the case of the Tasmanian eucalypts. *Philosophical Transactions of the Royal Society of London - Series B: Biological Sciences.*

MORAN, G. F., THAMARUS, K. A., RAYMOND, C. A., QIU, D., UREN, T. & SOUTHERTON, S. G., 2002: Genomics of *Eucalyptus* wood traits. *Annales des Sciences Forestieres (Paris)* 59: 645–650.

MUELLER, F., 1879-84: *Eucalyptographia: A descriptive Atlas of the Eucalypts of Australia and the Adjoining Islands.* Government Printer, Melbourne. 10 parts.

MYBURG, A. A., GRIFFIN, A. R., SEDEROFF, R. R. & WHETTEN, R. W., 2003: Comparative genetic linkage maps of *Eucalyptus grandis, Eucalyptus globulus* and their F_1 hybrid based on a double pseudo-backcross mapping approach. *Theoretical and Applied Genetics* 107: 1028–1042.

NESBITT, K. A., POTTS, B. M., VAILLANCOURT, R. E., WEST, A. K. & REID, J. B., 1995: Partitioning and distribution of RAPD variation in a forest tree species, *Eucalyptus globulus* (Myrtaceae). *Heredity* 74: 628–637.

ORME, R. K., 1977: *Eucalyptus globulus* provenances. *Third World Consultation on Forest Tree Breeding, 21-26 Mar. 1977.* (CSIRO, Canberra) IUFRO International Symposium Canberra, Australia: 207–222.

PATTERSON, B., VAILLANCOURT, R. E. & POTTS, B. M., 2001: Eucalypt seed collectors: beware of sampling seed lots from low in the canopy! *Australian Forestry* 64: 139-142.

PHILLIPS, R. L. & REID, J. B., 1980: Clinal variation between *Eucalyptus viminalis* Labill. and *E. dalrympleana* Maiden. *Australian Journal of Botany* 28: 329–342.

PILIPENKA, F. S., 1969: [Hybridisation of eucalypts in the USSR]. *Akademiya Nauk SSSR. Botanicheski Institut. Trudy 6th series. Introduktsiya Rastenii Zelende Stroitel'stvd* 9: 5-68. (Translated by P. Auckland, CSIRO: Melbourne).

POKE, F., VAILLANCOURT, R., ELLIOTT, R. & REID, J., 2003: Sequence variation in two lignin biosynthesis genes, cinnamoyl CoA reductase (CCR) and cinnamyl alcohol dehydrogenase 2 (CAD2). *Molecular Breeding* 12: 107–118.

POTTS, B. M., 1988: The distribution and type locality of *Eucalyptus cordata* Labill. - an historical account. *Papers and Proceedings of the Royal Society of Tasmania* 122: 31–38.

POTTS, B. M., 1989: *Population variation and conservation status of*

a rare Tasmanian endemic, Eucalyptus cordata. Tasmanian Forest Research Council Inc., Hobart: 140 pp.

Potts, B. M. & Jackson, W. D., 1986: Evolutionary processes in the Tasmanian high altitude eucalypts. *In* Barlow, B. A. (Ed.): *Flora and Fauna of Alpine Australasia. Ages and Origins,* CSIRO, Melbourne: 511–527.

Potts, B. M. & Potts, W. C., 1986: Eucalypt breeding in France. *Australian Forestry* 49: 210–218.

Potts, B. M., Potts, W. C. & Kantvilas, G., 2001: The Miena cider gum, *Eucalyptus gunnii* subsp. *divaricata* (*Myrtaceae*): a taxon in rapid decline. *Papers and Proceedings of the Royal Society of Tasmania* 135: 57–61.

Potts, B. M., & Reid, J. B., 1985a: Variation in the *Eucalyptus gunnii-archeri* complex. I. Variation in the adult phenotype. *Australian Journal of Botany* 33: 337–359.

Potts, B. M. & Reid, J. B., 1985b: Variation in the *Eucalyptus gunnii-archeri* complex. II. The origin of variation. *Australian Journal of Botany* 33: 519–541.

Potts, B. M. & Reid, J. B., 1988: Hybridisation as a dispersal mechanism. *Evolution* 42: 1245–1255.

Potts, B. M., Volker, P. W., Tilyard, P. A. & Joyce, K., (2000): The genetics of hybridisation in the temperate *Eucalyptus. In* Dungey, H. D., Dieters, M. J. & Nikles, D. G. (Eds): *Hybrid Breeding and Genetics of Forest Trees. Proceedings of QFRI/CRC-SPF Symposium, 9-14 April 2000, Noosa, Queensland, Australia.* Queensland Department of Primary Industries, Brisbane: 200–211.

Pound, L. M., Wallwork, M. A. B., Potts, B. M. & Sedgley, M., 2002: Self-incompatibility in *Eucalyptus globulus* ssp. *globulus* (Myrtaceae). *Australian Journal of Botany* 50: 365–372.

Pryor, L. D. & Johnson, L. A. S., 1971: *A classification of the eucalypts.* Australian National University Press, Canberra: 102 pp.

Raymond, C. A., 2001: Genetics of *Eucalyptus* wood properties. *Annals of Forest Science* 59: 525–531.

Rodway, L., 1903: *The Tasmanian flora.* Government Printer, Hobart: 320 pp.

Rodway, L., 1918: Tasmanian eucalypts. *Proceedings of the Royal Society of Tasmania* 1917: 10–20.

Sale, M. M., Potts, B. M., West, A. K. & Reid, J. B., 1993: Relationships within *Eucalyptus* using chloroplast DNA. *Australian Systematic Botany* 6: 127–138.

Savva, M., Potts, B. M. & Reid, J. B., 1988: The breeding system and gene flow in *Eucalyptus urnigera. In* Knox, R. B., Sing, M. B. & Troiani, L. F. (Eds): *Pollination '88,* Plant Cell Biology Research Centre, University of Melbourne, Melbourne: 176–182.

Schilder, G., 1988: New Holland: The Dutch discoveries. *In* Williams, G. & Frost A. (Ed.): *Terra Australis to Australia.* Oxford University Press, Melbourne: 83–115.

Shaw, M. J., Potts, B. M. & Reid, J. B., 1984: Variation within and between *Eucalyptus nitida* Hook.f. and *E. coccifera* Hook.f. *Australian Journal of Botany* 32: 641–654.

Somerville, J., 1964: History of Tasmanian Botany: 1642–1820. Unpublished manuscript, University of Tasmania.

Steane, D., Nicolle, D., Vaillancourt, R. & Potts, B., 2002: Higher level relationships among the eucalypts are resolved by ITS sequence data. *Australian Systematic Botany* 15: 49–62.

Steane, D. A., Byrne, M., Vaillancourt, R. E. & Potts, B. M., 1998: Chloroplast DNA polymorphism signals complex interspecific interactions in *Eucalyptus* (Myrtaceae). *Australian Systematic Botany* 11: 25–40.

Steane, D. A., Vaillancourt, R. E., Russell, J., Powell, W., Marshall, D. & Potts, B. M., 2001: Microsatellite variation in a forest tree, *Eucalyptus globulus* ssp. *globulus* (Myrtaceae). *Silvae Genetica* 50: 89–91.

Steane, D. A., West, A. K., Potts, B. M., Ovenden, J. M. & Reid, J. B., 1991: Restriction fragment length polymorphisms in chloroplast DNA from six species of *Eucalyptus. Australian Journal of Botany* 39: 399–414.

Taylor, H. G., 1973: *The discovery of Tasmania.* Cat & Fiddle Press, Hobart: 177 pp.

Thamarus, K., Groom, J., Murrell, M., Byrne, M. & Moran, G., 2002: A genetic linkage map for *Eucalyptus globulus* containing microsatellite and candidate gene loci and cambium specific espressed sequence tags (ESTs). *Theoretical and Applied Genetics* 104: 379–387.

Thomas, D. A. & Barber, H. N., 1974a: Studies on leaf characteristics of a cline of *Eucalyptus urnigera* from Mt Wellington, Tasmania. I. Water repellancy and the freezing of leaves. *Australian Journal of Botany* 22: 501–512.

Thomas, D. A. & Barber, H. N., 1974b: Studies on leaf characteristics of a cline of *Eucalyptus urnigera* from Mt Wellington, Tasmania. II. Reflection, transmission and absorption of radiation. *Australian Journal of Botany* 22: 701–707.

Turnbull, J., 1999: Eucalypt plantations. *New Forest* 17: 37-52.

Turner, C., Wiltshire, R. J. E., Potts, B. M. & Vaillancourt, R. E., 2001: Variation in seedling morphology in the *Eucalyptus risdonii* Hook. f - *E. tenuiramis* Miq. complex. *Australian Systematic Botany* 49: 43–54.

Vaillancourt, R. E. & Jackson, H. D., 2000: A chloroplast DNA hypervariable region in eucalypts. *Theoretical and Applied Genetics* 101: 473–477.

Vaillancourt, R. E., Potts, B. M., Manson, A. & Reid, J. B., 1994: Detection of QTL's in a *Eucalyptus gunnii* x *E. globulus* F_2 using a RAPD linkage map. *Proceedings of the International Symposium of Wood Biotechnology (ISWB),* Tokyo, Japan, August 31-Sept 1, 1994. Tokyo, Japan: 63–70.

Volker, P., 2002: Quantitative genetics of *Eucalypus globulus, E. nitens* and their F_1 hybrid. Unpublished PhD thesis. Univeristy of Tasmania, Hobart.

Walker, J. B., 1891: *The discovery of Van Diemen's Land in 1642; with notes on the localities mentioned in Tasman's journal of the Voyage.* Government Printer, Hobart: 16 pp.

Wallis, H., 1988: Java la Grande: The enigma of the Dieppe maps. *In* Williams, G. and Frost, A. (Eds): *Terra Australis to Australia.* Oxford University Press, Melbourne: 39–80.

Williams, D. R., Potts, B. M. & Black, P. G., 1999: A single visit pollination method for *Eucalyptus globulus. Australian Forestry* 62: 346–352.

Williams, J. E. & Woinarski, J. C. Z., 1997: *Eucalypt Ecology: Individuals to Ecosystems.* Cambridge University Press, Cambridge: 430 pp.

Williams, K. & Potts, B. M., 1996: The natural distribution of *Eucalyptus* species in Tasmania. *Tasforests* 8: 39–164.

Wilson, R. C., 1975: Robert Gordon Lindsay Brett — some reflections on his life and work as an educationist in Tasmania. *Tasmanian Journal of Education* 9: 58–59.

Wiltshire, R. J. E., Potts, B. M. & Reid, J. B., 1991: A paedomorphocline in *Eucalyptus*: Natural variation in the *E. risdonii*/*E. tenuiramis* complex. *Australian Journal of Botany* 39: 545–566.

Wiltshire, R. J. E., Potts, B. M. & Reid, J. B., 1992: A paedomorphocline in *Eucalyptus*: II. Variation in seedling mor-

phology in the *E. risdonii/tenuiramis* complex. *Australian Journal of Botany* 40: 789–805.

WILTSHIRE, R. J. E., POTTS, B. M. & REID, J. B., 1998: Genetic control of reproductive and vegetative phase change in the *Eucalyptus risdonii-E. tenuiramis* complex. *Australian Journal of Botany* 46: 45–63.

WILTSHIRE, R. J. E. & REID, J. B., 1987: Genetic variation in the Spinning Gum, *Eucalyptus perriniana* F. Muell. ex Rodway. *Australian Journal of Botany* 35: 33–47.

WOOD, M. S., STEPHENS, N. C., ALLISON, B. K. & HOWELL, C. I., 2001: *Plantations of Australia - A report from the National Plantation Inventory and the National Farm Forest Inventory.* Bureau of Rural Sciences, Canberra: 72 pp.

WRIGHT, S., 1948: On the role of directed and random changes in gene frequency in the genetics of populations. *Evolution* 2: 279–294.

ZACHARIN, R. F., 1978: *Emigrant eucalypts: gum trees as exotics.* Melbourne University Press, Melbourne:137 pp.

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INDEX OF CHROMOSOME NUMBERS OF TASMANIAN SPERMATOPHYTES

by R.J.E. Wiltshire and the late W.D. Jackson

(with two tables)

WILTSHIRE, R.J.E. & JACKSON, W.D., 2003 (19.xii): Index of chromosome numbers of Tasmanian spermatophytes. *Papers and Proceedings of the Royal Society of Tasmania* 137: 39–53. ISSN 0080-4703. School of Plant Science, University of Tasmania, Private Bag 55, Hobart, Tasmania 7001, Australia.

A preliminary index of chromosome numbers for spermatophytes indigenous to Tasmania is presented, with reference citations. This compilation includes reports for 166 species provenanced from Tasmanian material, many previously published, and also 55 unpublished results (mostly from the work of WDJ). Selected reports of species indigenous to Tasmania but derived elsewhere (usually material from New Zealand or the Australian mainland) are also included as a basis for further study. In total, chromosome numbers are listed for 400 species (409 taxa, including subspecies and varieties) out of a total estimated spermatophyte flora of 1568 described indigenous species. Ten of the 108 families have been examined in some detail (>45% of species), but the four most speciose families (625/1568 species; Orchidaceae, Asteraceae, Poaceae and Cyperaceae) have a total of only four Tasmanian reports, despite highly variable chromosome complements. Five other speciose families (Apiaceae, Brassicaceae, Juncaceae, Rhamnaceae and Scrophulariaceae) have no Tasmanian reports despite demonstrating cytological variability at generic, inter- and intra-specific levels. Further cytological investigation of these taxa is essential for a clearer understanding of the Tasmanian flora.

Key Words: chromosome numbers, cytology, plants, Tasmania, spermatophytes.

INTRODUCTION

This index is a preliminary attempt to catalogue the existing reports of the chromosome numbers of spermatophytes (seed plants) indigenous to Tasmania and, in doing so, mark the contribution of the late Professor Bill (William Dalziel) Jackson. Bill Jackson's contribution to our understanding of Tasmanian botany, both as an inspirational teacher and as a researcher in the fields of ecology and eucalypt genetics, is without peer and is widely known. Bill's cytological investigation of the Tasmanian flora is less widely appreciated, since it was a focus of his early research career in the late 1950s and early 1960s, and because only a fraction of the work was formally published.

Bill Jackson's cytological studies were a continuation of an area of study with a long history at the University of Tasmania. This work was commenced not in the Botany Department but in the Physics Department with the early work of F.D. Cruickshank and Professor A.L. McAulay (McAulay *et al.* 1936, McAulay 1937, McAulay & Cruickshank 1937), who made some of the first investigations of the eucalypt chromosome complement and behaviour during meiosis. A major impetus to cytological investigation of other elements of the Tasmanian flora was the appointment of cytogeneticist Horace Newton Barber (trained as a research cytologist at the John Innes Horticultural Institute, 1936–1940) as the inaugural Professor of Botany at the University of Tasmania (1947–1963). Barber supervised a number of postgraduate students in cytological studies during the 1950s and 1960s, including H.F. Gulline, C. Venkata Rao and W.D. Jackson. However, some of the results of these studies remained unpublished (particularly those of W.D. Jackson) or were reported in informal ways.

This paper catalogues some of these determinations of chromosome numbers of the Tasmanian flora by W.D. Jackson, his contemporaries and his students. Where possible, these previously unpublished reports are supported by collection numbers for material lodged in the Tasmanian Herbarium (HO) and/or by published reports from locations on the Australian mainland, New Zealand or other localities.

Reports of chromosome numbers were available for 166 (of an estimated 1568, from Buchanan 2002) indigenous spermatophyte species from material collected in Tasmania. In addition, selected reports were included for material from non-Tasmanian provenances as a basis for further studies, increasing the number of species for which chromosome numbers have been determined to 400 or 26% of the spermatophyte flora of Tasmania. This was made possible by the comprehensive listing of chromosome numbers in the *Index of chromosome numbers of indigenous New Zealand spermatophytes* compiled by Dawson (2000), from which many reports of non-Tasmanian material have been drawn, and which we gratefully acknowledge.

CONVENTIONS FOLLOWED

Chromosome numbers are reported from species indigenous to Tasmania, following Buchanan (2002). Reports are derived from material of Tasmanian origin, where possible, but otherwise chromosome numbers are reported from Australia or New Zealand (or other sources, if variable), although not all reports from non-Tasmanian provenances are cited.

Previously unpublished reports of chromosome numbers from Tasmanian provenances are included, supplemented by published reports from other provenances. Herbarium specimens lodged at the Tasmanian Herbarium (HO) are recorded if available, using the *HO* specimen number, or the collector's specimen number, e.g. *(Brown 1004)* or W.D. Jackson unpub *(3867)*.

Taxonomic groups with extensive nomenclatural revisions, particularly in the Poaceae, may be incompletely reported for chromosome counts not recorded from Tasmanian material.

Nomenclature used in table 1 follows Buchanan (2002), where synonyms are listed.

The authors have not validated all original reports cited in table 1. Many are derived from collations of chromosome numbers, including Darlington & Wylie (1955) and supplementary volumes of the *Index to Plant Chromosome Numbers* (IPCN), and reports from 1986 onward have been derived from the *Index to Plant Chromosome Numbers* project based at the Missouri Botanical Garden, accessed during November 2002 (http://mobot.mobot.org/W3T/Search/ipcn.htm). The original sources of many reports of non-Tasmanian material (particularly New Zealand records) have been drawn from *Index of chromosome numbers of indigenous New Zealand spermatophytes* compiled by Dawson (2000).

RESULTS

Chromosome counts from 166 species recorded from Tasmanian material, including 55 previously unpublished reports, are listed in table 1. Counts are also reported for an additional 234 species of spermatophytes indigenous to Tasmania, but derived from material from other localities, giving a total of 400 species or 26% of the estimated indigenous spermatophyte flora. There is a very uneven representation of families assayed for chromosome number, however, with several families comprehensively studied (Cupressaceae, Podocarpaceae, Plantaginaceae and Ranunculaceae). But 45 of 108 families have no records for species found in Tasmania (table 2). The chromosome counts for Tasmanian material are particularly poor for the four most speciose families (625/1568 species; Orchidaceae, Asteraceae, Poaceae and Cyperaceae).

In other locations, these families and many other families indigenous to Tasmania show evidence of chromosome number variability (tables 1, 2). A conservative estimate of variation in ploidy within families is 46%, and a similar proportion of families show variation in chromosome number between genera (44%), between species (33%) and even within species (20%).

DISCUSSION

The aim of this paper is to provide those working with the Tasmanian flora with convenient access to the chromosome numbers of species published to date, and to include unpublished reports. Although these reports total 26% of the indigenous Tasmanian seed plants, only 11% of these were from Tasmanian-provenanced material and the representation of the flora is very uneven. Six families have been surveyed extensively, usually because of concerted individual effort: Cupressaceae (6/6 species by H.F. Gulline and Y. Sundar Rao); Liliaceae (16/38 species by W.D. Jackson and W.M. Curtis); Podocarpaceae (5/5 species by Y. Sundar Rao); Proteaceae (17/28 species by C. Venkata Rao); Ranunculaceae (22/23 species by Y. Menadue and R.K. Crowden); Thymeliaceae (13/19 species by F.D. Cruickshank). The records from these six families comprise nearly half (79/166) of all the Tasmanian counts.

In contrast, there are only four chromosome counts recorded from Tasmanian material of the four most speciose families (Orchidaceae, Asteraceae, Poaceae and Cyperaceae) that comprise 40% of the Tasmanian seed plants. Cytological studies in these groups would be valuable, given the high level of endemism, and the prevalence of polyploidy and variation in chromosome number in all four families.

The other families well represented in the Tasmanian flora, with variable chromosome complements recorded elsewhere, but few or no records in Tasmania, include: Apiaceae (39 species), Brassicaceae (20 species), Epacridaceae (89 species), Fabaceae (53 species), Juncaceae (33 species), Rhamnaceae (23 species), Rutaceae (22 species) and Scrophulariaceae (24 species). Clearly, there is scope for additional cytological studies that will contribute to our understanding of the evolution of the Tasmanian flora.

Tables 1 and 2 follow on pages 41–49.

TABLE 1
Chromosome numbers of indigenous Tasmanian spermatophytes

Family	Species	Locality	n	2n	Authority
AIZOACEAE (FICOIDEAE)	*Tetragonia tetragonoides* (Pallas) Kuntze	*aTaiwan, bNZ, cPortugal	8a, 16b	16c	aHsu 1968, bHair & Beuzenberg 1959, cJ.E. Rodrigues in Moore 1982
APIACEAE	*Apium annuum* P.S.Short	*Australia		22	Short 1979
APIACEAE	*Apium prostratum* Labill. ex Vent.,	*Australia	11		Bell & Constance 1966
	var. *filiforme* (A.Rich.) Kirk	*NZ	11	22	Beuzenberg & Hair 1963
APIACEAE	*Hydrocotyle pterocarpa* F.Muell.	*unknown		48	Hair 1980a
APIACEAE	*Hydrocotyle sibthorpioides* Lamk.	*unknown		24	Hamal *et al.* 1986
APIACEAE	*Hydrocotyle tripartita* R.Br. ex A.Rich.	*NZ		24	Webb & Beuzenberg 1987
ASTERACEAE	*Abrotanella forsteroides* (Hook.f.) Benth.	Mt Wellington, Dove L.		36	Beuzenberg & Hair 1984
ASTERACEAE	*Abrotanella scapigera* (F.Muell.) Benth.	Mt Field West, Cradle Mt		18	Beuzenberg & Hair 1984
ASTERACEAE	*Bedfordia linearis* DC.	Tasmania		60	Beuzenberg 1975
ASTERACEAE	*Brachyscome aculeata* (Labill.) Less.	*Australia	9a, 9IIb, 18II+2Bb	18b	aStace 1981, bWatanabe *et al* . 1996
ASTERACEAE	*Brachyscome angustifolia* A.Cunn. ex DC.	*Australia	5II	10	Watanabe *et al* . 1996
ASTERACEAE	*Brachyscome cardiocarpa* F.Muell. ex Benth.	*Australia		36	Watanabe *et al* . 1996
ASTERACEAE	*Brachyscome decipiens* Hook.f.	*Australia	9II,	18	Watanabe *et al* . 1996
ASTERACEAE	*Brachyscome diversifolia* (Graham ex Hook.) Fisch. &				
	var. *diversifolia*	*Australia		24	Watanabe & Short 1992
ASTERACEAE	*Brachyscome graminea* (Labill.) F.Muell.	*Australia	9II	18	Watanabe *et al* . 1996
ASTERACEAE	*Brachyscome perpusilla* (Steetz) J.M.Black	*Australia		18	Watanabe *et al* . 1996
ASTERACEAE	*Brachyscome radicans* Steetz in Lehm.	*Australia	13II	26	Watanabe *et al* . 1996
ASTERACEAE	*Brachyscome radicata* Hook.f.	*NZ		90	Beuzenberg & Hair 1984
ASTERACEAE	*Brachyscome rigidula* (DC.) G.Davis	*Australia	9II	18	Watanabe *et al* . 1996
ASTERACEAE	*Brachyscome spathulata* Gaud. in Freycinet	*Australia	9II,27II	18	Watanabe *et al* . 1996
	subsp. *glabra*	*Australia	9	18	Stace 1981
	subsp. *spathulata*	*Australia	9, 18, 27, 36. 45	18	Stace 1981
ASTERACEAE	*Brachyscome tenuiscapa* Hook.f.				
	var. *tenuiscapa*	*Australia	9II,27II	18	Watanabe *et al* . 1996
ASTERACEAE	*Celmisia asteliifolia* Hook.f.	*Australia	54, 108	108,216	Hair 1980
ASTERACEAE	*Centipeda elatinoides* (Less.) Benth. & Hook. ex	*India		20	Gupta & Gill 1989
ASTERACEAE	*Cotula australis* (Sieber ex Sprengel) Hook.f.	*aAustralia, bunknown. cNZ	a20, b18	c36	aDavis 1962, b Keil 1979, cBeuzenberg & Hair 1984
ASTERACEAE	*Euchiton traversii* (Hook.f.) Holub	*NZ		28	Groves 1977
ASTERACEAE	*Lagenophora huegelii* Benth. in Endl.	*Australia		18	Watanabe *et al* . 1996
ASTERACEAE	*Lagenophora stipitata* (Labill.) Druce	*Australia	9II	18	Watanabe *et al* . 1996
ASTERACEAE	*Olearia algida* N.A.Wakef.	*Australia		18	Beuzenberg & Hair 1984
ASTERACEAE	*Olearia ciliata* (Benth.) F.Muell. ex Benth.	*Australia	9II		Watanabe *et al* . 1996
ASTERACEAE	*Olearia phlogopappa* (Labill.) DC.	*Australia	18II		Watanabe *et al* . 1996
ASTERACEAE	*Olearia ramulosa* (Labill.) Benth.	*Australia	9II		Watanabe *et al* . 1996
ASTERACEAE	*Picris angustifolia* DC.				
	subsp. *angustifolia*	*Australia		10	Holzapfel 1994
	subsp. *merxmuelleri* Lack & S.Holzapfel	*aNZ, bAustralia	5IIa	10b	aMurray & de Lange 1999, bHolzapfel 1994
ASTERACEAE	*Pseudognaphalium luteo-album* (L.) Hilliard & B.L.Burtt	*aAustralia, bNZ	7a	14b	aTurner 1970, bGroves 1977,bDawson & Beuzenberg 2000
ASTERACEAE	*Senecio biserratus* Belcher	*aAustralia, bNZ	50a	c. 96, 100b	aLawrence 1985, bBeuzenberg & Groves 1974
ASTERACEAE	*Senecio glomeratus* Desf. ex Poiret	*aAustralia, bNZ	30a	60b	aLawrence 1985, bBeuzenberg & Groves 1974
ASTERACEAE	*Senecio gunnii* (Hook.f.) Belcher	*Australia	30	60	Lawrence 1980
ASTERACEAE	*Senecio hispidulus* A.Rich.	*aAustralia, bNZ	30a	60b	aLawrence 1985, bBeuzenberg & Groves 1974
ASTERACEAE	*Senecio linearifolius* A.Rich.	*Australia	30	60	Lawrence 1980
ASTERACEAE	*Senecio minimus* Poiret	*aAustralia, bNZ	30a	60b	aLawrence 1985, bBeuzenberg & Groves 1974
ASTERACEAE	*Senecio quadridentatus* Labill.	*aAustralia, bNZ	20a	40b	aTurner 1970, bBeuzenberg & Groves 1974
ASTERACEAE	*Senecio odoratus* Hornem.	*Australia	30	60	Lawrence 1980
ASTERACEAE	*Senecio orarius* J.Black	*Australia		70	Lawrence 1980
ASTERACEAE	*Senecio pectinatus* DC	*Australia	40	80	Lawrence 1980
ASTERACEAE	*Senecio spathulatus* A.Rich.	*Australia	20	40	Lawrence 1980
ASTERACEAE	*Senecio squarrosus* A.Rich.	*Australia	30	60	Lawrence 1980
ASTERACEAE	*Senecio vagus* F.Muell.	*Australia	49	98	Lawrence 1980
ASTERACEAE	*Solenogyne dominii* L.Adams	*Australia	9a	18b	aAdams 1979, bWatanabe *et al* . 1996
ASTERACEAE	*Solenogyne gunnii* (Hook.f.) Cabrera	*Australia	9		Adams 1979
ASTERACEAE	*Taraxacum aristum* Hagl. & Markl.	*unknown		16	Hughes & Richards 1988
ASTERACEAE	*Vittadinia cuneata* DC.	*Australia	9II	18	Watanabe *et al* . 1996
ASTERACEAE	*Vittadinia gracilis* (Hook.f.) N.Burb.	*Australia	9II		Watanabe *et al* . 1996
ASTERACEAE	*Vittadinia muelleri* N.Burb.	*Australia	9II		Watanabe *et al* . 1996
ASTERACEAE	*Xerochrysum bracteatum* (Vent.) Tzvelev	*unknown	13		Gupta & Gill 1981 .
BRASSICACEAE	*Cardamine aff. corymbosa* Hook.f., sensu H.J.Hewson	*NZ		48	Moore 1960
BRASSICACEAE	*Lepidium hyssopifolium* Desv.	*unknown		32	Johnson 1993
BRUNONIACEAE	*Brunonia australis* Smith ex R.Br	aQueechy Hill, bvarious locations	9a	18a, 36b	aJackson 1958, bPeacock 1963
CAMPANULACEAE	*Isotoma fluviatilis* (R.Br.) F.Muell	*abAustralia, cNZ	7a	14a, 28bc	Stace & James 1996, bMcComb 1970, cBeuzenberg & Hair 1983
CAMPANULACEAE	*Lobelia anceps* L.f.	*Australia	7	14	Stace & James 1996
CAMPANULACEAE	*Lobelia gibbosa* Labill.	*Australia	10		Stace & James 1996
CAMPANULACEAE	*Lobelia pratioides* Benth.	*Australia	7,21	14,42	Stace & James 1996
CAMPANULACEAE	*Lobelia rhombifolia* Vriese in Lehm.	*Australia	10		Stace & James 1996
CAMPANULACEAE	*Pratia irrigua* (R.Br.) Benth.	*Australia	21		Stace & James 1996
CAMPANULACEAE	*Pratia pedunculata* (R.Br.) Benth.	*NZ		28	Murray et al. 1992

Table 1 cont.

Family	Species	Locality	n	2n	Authority
CAMPANULACEAE	*Pratia surrepens* (Hook.f.) F.E.Wimmer	*Australia	14,21	28,42	Stace & James 1996
CAMPANULACEAE	*Wahlenbergia ceracea* Loth.	*Australia	9		Smith 1992
CAMPANULACEAE	*Wahlenbergia gracilenta* Loth.	aTasmania, *bAustralia		18	aHF Gulline unpub, bSmith 1992
CAMPANULACEAE	*Wahlenbergia gracilis* (Forst.f.) A.DC.	aTasmania, *bAustralia		18	aHF Gulline unpub, bSmith 1992
CAMPANULACEAE	*Wahlenbergia gymnoclada* Loth.	aTasmania, *bAustralia	9b	18a	aHF Gulline unpub, bSmith 1992
CAMPANULACEAE	*Wahlenbergia littoricola* P.J.Smith in Jessop & Tolken	*Australia	27, 36		Smith 1992
CAMPANULACEAE	*Wahlenbergia multicaulis* Benth. in Endl.	*Australia	18, 27, 36		Smith 1992
CAMPANULACEAE	*Wahlenbergia saxicola* A.DC.	Mt Wellington		72	HF Gulline unpub
CAMPANULACEAE	*Wahlenbergia stricta* (R.Br.) Sweet	Tasmania		36	HF Gulline unpub
CARYOPHYLLACEAE	*Colobanthus affinis* (Hook.) Hook.f	*NZ	c. 40		Sneddon in Dawson & Beuzenberg 2000
CARYOPHYLLACEAE	*Scleranthus biflorus* (Forst. & Forst.f.) Hook.f.,	*NZ		48	Beuzenberg & Hair 1983
CARYOPHYLLACEAE	*Scleranthus brockiei* P.A.Williamson	*NZ		48	Beuzenberg & Hair 1983
CARYOPHYLLACEAE	*Spergularia media* (L.) C.Presl	*unknown		18	Labadie 1976
CASUARINACEAE	*Allocasuarina littoralis* (Salisb.) L.A.S.Johnson	aTasmania, bc*Australia		22c, 44c, 48ab.	aN Purcell unpub, bMorawetz & Samuel 1989, cBarlow 1958
CASUARINACEAE	*Allocasuarina monilifera* (L.A.S.Johnson) L.A.S.Johnson	aTasmania, *bAustralia		22b,44a	aN Purcell unpub, bBarlow 1959
CASUARINACEAE	*Allocasuarina paludosa* (Sieber ex Sprengel) L.A.S.John	*Australia		22b, 44b, 52a	N Purcell unpub, bBarlow 1959
CASUARINACEAE	*Allocasuarina verticillata* (Lam.) L.A.S.Johnson	Hobart		26	N Purcell unpub, Barlow 1959
CENTROLEPIDACEAE	*Centrolepis fascicularis* Labill.	near Smithton	13	26	Briggs 1966
CHENOPODIACEAE	*Atriplex billardierei* (Moq.) Hook.f.	*NZ	9, 9II		de Lange *et al.* 1997
CHENOPODIACEAE	*Atriplex cinerea* Poiret in Lam.,	*NZ	27II		de Lange et al. 1998
CHENOPODIACEAE	*Sarcocornia quinqueflora* (Bunge ex Ung.-Sternb.)	*NZ	9	18	Hair & Beuzenberg 1960
CLUSIACEAE	*Hypericum gramineum* Forst.f.	*NZ	8		Hair & Beuzenberg 1959
CLUSIACEAE	*Hypericum japonicum* Thunb.	*NZ	8		Hair & Beuzenberg 1959
CONVOLVULACEAE	*Calystegia sepium* (L.) R.Br.	*cosmopolitan	11	22	many in Dawson 2000
CONVOLVULACEAE	*Calystegia soldanella* (L.) R.Br.	*cosmopolitan	11	22	many in Dawson 2000
CONVOLVULACEAE	*Dichondra repens* Forst. & Forst.f.	*aNZ, bTaiwan	15a	30a, 24b	aHair 1963,bHsu 1967
CRASSULACEAE	*Crassula moschata* Forst.f.	*aNZ, bSouth Africa		28a, b32	aMoore 1960, bMerxmuller *et al.* 1971
CRASSULACEAE	*Crassula peduncularis* (Smith) Meigen	*NZ		42	Murray & de Lange 1999
CUNONIACEAE	*Bauera rubioides* Andrews	*Australia		32	S Smith-White in Darlington & Wylie 1955
CUPRESSACEAE	*Athrotaxis cupressoides* D.Don	National Park, Pine Valley, Hartz Mt	11a	22ab	aGulline 1952, bSundar Rao 1959
CUPRESSACEAE	*Athrotaxis laxifolia* Hook.	National Park, Cradle Mt	11a	22ab	aGulline 1952, bSundar Rao 1959
CUPRESSACEAE	*Athrotaxis selaginoides* D.Don	National Park, Wylds Craig, Cradle Mt, Hartz Mt	11a	22ab	aGulline 1952, bSundar Rao 1959
CUPRESSACEAE	*Callitris oblonga* Rich.	Tasmania		22	Sundar Rao 1959
CUPRESSACEAE	*Callitris rhomboidea* R.Br. ex Rich.	Tasmania	11a	22	aHF Gulline unpub, Sundar Rao 1959
CUPRESSACEAE	*Diselma archeri* Hook.f.	Tasmania		22	Sundar Rao 1959
CYPERACEAE	*Bolboschoenus caldwellii* (V.Cook) Soják	*unknown		*c.* 90	Harriman 1981
CYPERACEAE	*Bolboschoenus medianus* (V.Cook) Soják	*unknown		*c.* 94	Harriman 1981
CYPERACEAE	*Carex albula* Allan	*NZ		*c.* 60	Dawson & Beuzenberg 2000
CYPERACEAE	*Carex breviculmis* R.Br.	*Japan	34a	64a, 72b	aTanaka 1939, bOkuno 1939
CYPERACEAE	*Carex curta* Gooden	*Mediterranean		56	Stoeva 1994
CYPERACEAE	*Carex pumila* Thunb. ex Murr.	*Japan	41	82	Tanaka 1939
CYPERACEAE	*Eleocharis acuta* R.Br.	*aNZ, bAustralia		20a, 40b	Briggs 1970
CYPERACEAE	*Eleocharis gracilis* R.Br.	*Australia		20	Briggs 1970
CYPERACEAE	*Eleocharis pusilla* R.Br.	*Australia		30	Briggs 1970
CYPERACEAE	*Eleocharis sphacelata* R.Br.	*Australia		94-100, c. 140, c. 157, 176-184, *c.* 188	Briggs 1970
CYPERACEAE	*Isolepis aucklandica* Hook.f.	*NZ	21	42	Moore 1960
CYPERACEAE	*Isolepis setacea* (L.) R.Br.	*Slovakia		28	Mi_jeta 1986
CYPERACEAE	*Lepidosperma gunnii* Boeck.	Mt Nelson	108		WD Jackson unpub 3867
CYPERACEAE	*Schoenoplectus pungens* (M.Vahl) Palla	*aUSA, bCanada		74a, 78b	aHarriman 1981, bLöve & Löve 1981
CYPERACEAE	*Schoenoplectus validus* (M.Vahl) A. & D.Löve	*Cosmopolitan	19,20,21	38,40,42,80	many in Dawson 2000
DROSERACEAE	*Drosera binata* Labill	*Australia		32a, 46b	aRothfels & Heimburger 1968, bKondo 1969
DROSERACEAE	*Drosera glanduligera* Lehm	*Australia		22	Kondo & Oliver 1979
DROSERACEAE	*Drosera macrantha* Endl.	*Australia		30	Kondo & Lavarack 1984
DROSERACEAE	*Drosera peltata* Thunb.	*aThailand, bJapan	16a, 20b		aLarsen 1966, bKondo 1969
DROSERACEAE	*Drosera spatulata* Labill.	*aNZ, bJapan, cAustralia	10a	20a,40bc, 60b. 80d	aBeuzenberg & Hair 1983, bc many in Dawson 2000, dRothfels & Heimburger 1968
EPACRIDACEAE	*Acrotriche serrulata* (Labill.) R.Br.	*Australia	9		Smith-White 1948
EPACRIDACEAE	*Astroloma humifusum* (Cav.) R.Br	Tasmania		24	Smith-White 1948
EPACRIDACEAE	*Astroloma pinifolium* (R.Br.) Benth.	*E. Australia	7	14	Smith-White 1948
EPACRIDACEAE	*Cyathodes glauca* Labill.	National Park		24	Smith-White 1955

Table 1 cont.

Family	Species	Locality	n	2n	Authority
EPACRIDACEAE	*Epacris impressa* Labill.	*Australia	13		Smith-White 1955
EPACRIDACEAE	*Epacris obtusifolia* Smith	*Australia	13		Smith-White 1948
EPACRIDACEAE	*Epacris paludosa* R.Br	*Australia	13		Smith-White 1948
EPACRIDACEAE	*Epacris serpyllifolia* R.Br.	aNational Park, *bAustralia	13b, 26a		Smith-White 1955
EPACRIDACEAE	*Leptecophylla divaricata* (Hook.f.) C.M.Weiller	National Park		24	Smith-White 1955
EPACRIDACEAE	*Leptecophylla juniperina* (Forst. & Forst.f.) C.M.Weiller subsp. *juniperina*	*NZ	11a	20b	aSands 1960, bDawson2000
EPACRIDACEAE	subsp. *parvifolia* (R.Br.) C.M.Weiller	National Park, Mt Wellington		20	Smith-White 1955
EPACRIDACEAE	*Leucopogon australis* R.Br.	*W. Australia	12		Smith-White 1955
EPACRIDACEAE	*Leucopogon ericoides* (Smith) R.Br.	*Australia	6	12	Smith-White 1948
EPACRIDACEAE	*Leucopogon esquamatus* R.Br.	*Australia	4	8	Smith-White 1948
EPACRIDACEAE	*Leucopogon hookeri* Sonder	*Australia	14	28	Smith-White 1955
EPACRIDACEAE	*Leucopogon lanceolatus* (Smith) R.Br.	*Australia	24		Smith-White 1948
EPACRIDACEAE	*Leucopogon montanus* (R.Br.) J.H.Willis	*Australia		28,42	S Smith-White in Darlington & Wylie 1955
EPACRIDACEAE	*Leucopogon parviflorus* (Andrews) Lindley	*NZ	11a	22b	aSands 1960, bDawson2000
EPACRIDACEAE	*Leucopogon virgatus* (Labill.) R.Br.	*Australia	10	20	Smith-White 1948
EPACRIDACEAE	*Lissanthe strigosa* (Smith) R.Br.	*Australia	7		Smith-White 1948
EPACRIDACEAE	*Monotoca elliptica* (Smith) R.Br.	*Australia	12	24	Smith-White 1948
EPACRIDACEAE	*Monotoca scoparia* (Smith) R.Br.	*Australia	12		Smith-White 1948
EPACRIDACEAE	*Pentachondra pumila* (Forst. & Forst.f.) R.Br.	*aAustralia, bNZ		a28, b52.c.52	aSmith-White 1955, bDawson2000
EPACRIDACEAE	*Planocarpa petiolaris* (DC.) Weiller	National Park		24	Smith-White 1955
EPACRIDACEAE	*Richea dracophylla* R.Br.	National Park	13		Smith-White 1955
EPACRIDACEAE	*Richea gunnii* Hook.f.	National Park	13		Smith-White 1955
EPACRIDACEAE	*Richea pandanifolia* Hook.f.	National Park	13		Smith-White 1955
EPACRIDACEAE	*Richea scoparia* Hook.f.	National Park	13	26	Smith-White 1955
EPACRIDACEAE	*Richea sprengelioides* R.Br.	National Park	13		Smith-White 1955
EPACRIDACEAE	*Sprengelia incarnata* Smith	aBlackmans Bay, bAustralia	12b	24a	aCurtis unpub, bSmith-White 1948
ERICACEAE	*Gaultheria depressa* Hook.f.	*NZ	11	22	Armstrong 1964
ERICACEAE	*Gaultheria hispida* R.Br.	*Australia		22	Callan 1941
ERICACEAE	*Gaultheria tasmanica* (Hook.f.) Middleton	Tasmania		22	Callan 1941, Middleton & Wilcock 1990
FABACEAE	*Glycine clandestina* J.Wendl.	*unknown		40	Lackey 1980, Halvankar & Patil 1990
FABACEAE	*Glycine latrobeana* (Messin.) Benth.	*unknown		40	Singh *et al.* 1988
FABACEAE	*Glycine microphylla* (Benth.) Tind.	*unknown		40	Singh *et al.* 1988
FABACEAE	*Pultenaea daphnoides* J.Wendl. var. *obcordata* (Andrews) Benth.	Tasmania		16	Curtis 1952
FABACEAE	*Hardenbergia violacea* (Schneev.) Stearn	*unknown		22	Lackey 1980
FABACEAE	*Pultenaea juniperina* Labill.	Lunawanna, Bruny I., Smithton, West Coast, Forestier Penn		18	Curtis 1952
		Eaglehawk Neck, Penzance		27	Curtis 1952
		Hobart, various locations		36	Curtis 1952
FABACEAE	*Pultenaea stricta* Sims	S.Tasmania		16	Curtis 1952
FABACEAE	*Pultenaea tenuifolia* R.Br. ex Sims	Bridport		16	Curtis 1952
FAGACEAE (NOTHOFAGACEAE)	*Nothofagus cunninghamii* (Hook.) Oersted	Mt Wellington (650m)	14	28	WD Jackson unpub (3878)
GERANIACEAE	*Geranium potentilloides* L'Hérit. ex DC.	*New Guinea		36, 56	Borgman 1964
GERANIACEAE	*Geranium sessiliflorum* Cav.	*unknown	28	56	Warburg 1938
GERANIACEAE	*Pelargonium inodorum* Willd.	*aNZ, bSouth Africa	11a	18b	aHair & Beuzenberg 1960, bVan der Walt & Vorster 1989
GOODENIACEAE	*Dampiera stricta* (Sm.) R.Br.	Bicheno	9	18	Jackson 1958
GOODENIACEAE	*Goodenia elongata* Labill.	St Helens	8	16	Jackson 1958
GOODENIACEAE	*Goodenia humilis* R.Br.	Low Head	8	16	Jackson 1958
GOODENIACEAE	*Goodenia lanata* R.Br.	Mt Nelson	8	16	Jackson 1958
GOODENIACEAE	*Goodenia ovata* Sm.	Tolosa St, Glenorchy	8	16	Jackson 1958
GOODENIACEAE	*Scaevola hookeri* (Vriese) F.Muell. ex Hook.f.	Mt Wellington	8	16	Jackson 1958
GOODENIACEAE	*Selliera radicans* Cav.	Glenorchy	8,24	16,48	Jackson 1958
	Selliera radicans Cav.	*NZ	8	16	Hair & Beuzenberg 1960
GOODENIACEAE	*Velleia montana* Hook.f.	King William Saddle	8	16	Jackson 1958
GOODENIACEAE	*Velleia paradoxa* R.Br.	Springfield, Glenorchy	8	16	Jackson 1958
HALORAGACEAE	*Gonocarpus micranthus* Thunb.	*aThailand, bJapan		12	Larsen 1966, bNishikawa 1989
HYDROCHARITACEAE	*Vallisneria americana* Mich.	*Japan		40	Uchiyama 1989
IRIDACEAE	*Diplarrena latifolia* Benth.	King William Saddle		32?	WD Jackson unpub (3866)
IRIDACEAE	*Diplarrena moraea* Labill.	aMt Nelson, b*unknown	15a	30-32b	aWD Jackson unpub (3865), bGoldblatt 1979
IRIDACEAE	*Libertia pulchella* Sprengel	*aNZ, bNew Guinea	19	38	aHair *et al.* 1967, b Borgmann 1964
IRIDACEAE	*Patersonia fragilis* (Labill.) Aschers & Graebner, Syn. Mitteleur	*unknown		42	Goldblatt 1979
IRIDACEAE	*Patersonia occidentalis* R.Br.	*unknown		22	Goldblatt 1979

Table 1 cont.

Family	Species	Locality	n	2n	Authority
JUNCACEAE	*Juncus bufonius* L.	*W.Europe	54a	106b	aCope & Stace 1985,bLove &Love 1980
JUNCACEAE	*Juncus falcatus* E.Meyer	*W.North America		c. 42	Chinnappa & Chmielewski 1987
JUNCACEAE	*Juncus gregiflorus* L.A.S.Johnson	*NZ		40	Beuzenberg & Hair 1983
JUNCACEAE	*Luzula australasica* Steudel	*Australasia		24	Collet & Westerman 1987
JUNCACEAE	*Luzula densiflora* (Nordensk.) Edgar	*Australasia		12	Collet & Westerman 1987
JUNCACEAE	*Luzula flaccida* (Buchenau) Edgar	*Australasia		12	Collet & Westerman 1987
JUNCAGINACEAE	*Triglochin procerum* R.Br.	*Australia		16b, 32ab, 62-64b	aBriggs 1966, bRobb & Ladiges 1981
JUNCAGINACEAE	*Triglochin striatum* Ruíz Lopez & Pavón	*aunknown, bNZ	12a	24b	aTalavera & García Murillo 1992, bMurray & de Lange 1999
LAURACEAE	*Cassytha pubescens* R.Br.	*Australia	24		Weber 1981
LEMNACEAE	*Lemna disperma* Hegelm.	*unknown		40	Urbanska-Worytkiewicz 1980
LEMNACEAE	*Lemna trisulca* L.	*unknown		20, 40, 60, 80	Urbanska-Worytkiewicz 1980
LEMNACEAE	*Wolffia australiana* (Benth.) Hartog & Plas	*NZ, Australia	20	40	Urbanska-Worytkiewicz 1980
LILIACEAE	Arthropodium milleflorum (DC.) J.F.Macbride	Tasmania		22	WD Jackson unpub
LILIACEAE	*Arthropodium minus* R.Br.	*unknown	11	22	Westphalen & Conran 1994
LILIACEAE	*Arthropodium strictum* R.Br.	bcTasmania	33a	66abc	aWestphalen & Conran 1994, bJackson unpub, cHF Gulline unpub
LILIACEAE	*Astelia alpina* R.Br.	Tasmania		c. 80	WD Jackson unpub
LILIACEAE	*Bulbine bulbosa* (R.Br.) Haw.	Tasmania		24,48	HF Gulline unpub
LILIACEAE	*Bulbine semibarbata* (R.Br.) Haw.	bTasmania		26abc	aStraub 1938, bHF Gulline unpub, cWatson 1988
LILIACEAE	*Chamaescilla corymbosa* (R.Br.) F.Muell. ex Benth.	Tasmania		44	WD Jackson unpub
LILIACEAE	*Dianella longifolia* R.Br. var. longifolia	Tasmania		16,32,48	Curtis 1952
LILIACEAE	Dianella revoluta R.Br.	Tasmania, many locations	8	16,32,48	Curtis 1952
LILIACEAE	Dianella tasmanica Hook.f.	Tasmania, many locations	8	76, 80, c. 80. 84	Curtis 1952
LILIACEAE	*Dianella tasmanica* Hook.f.	*Australia, several locations		16, 64	Curtis 1952
LILIACEAE	*Drymophila cyanocarpa* R.Br.	a Mt Lloyd, bTasmania		a24,b20	aMenadue & Orchard 1985 *(AM Buchanan 5648)* , bWD Jackson unpub
LILIACEAE	*Herpolirion novae-zelandiae* Hook.f.	Mathinna Plains		16	Menadue & Orchard 1985 *(AM Buchanan 5077)*
LILIACEAE	*Hypoxis glabella* R.Br. var. *glabella*	Tasmania		22	WD Jackson unpub
LILIACEAE	*Laxmannia orientalis* Keighery	Tasmania		16	WD Jackson unpub
LILIACEAE	*Thelionema caespitosum* (R.Br.) R.Henderson	Tasmania		18	WD Jackson unpub
LILIACEAE	*Thysanotus patersonii* R.Br.	Risdon Hill	44a	80	aWD Jackson unpub *(3850)*
LILIACEAE	*Wurmbea dioica* (R.Br.) F.Muell.	aTasmania, b*unknown		a20,40, b22	aWD Jackson unpub, bMacfarlane 1980
LYTHRACEAE	*Lythrum hyssopifolia* L.	*Spain	10		Silvestre 1986
LYTHRACEAE	*Lythrum salicaria* L.	*aJapan, bFinland		30a, 60b	aNishikawa 1989, bArohonka 1982
MIMOSACEAE	*Acacia dealbata* Link	*Australia	13a	26b	aKumari 1989, aSinghal 1990, bAtchison 1948
MIMOSACEAE	*Acacia melanoxylon* R.Br.	*unknown		26	Atchison 1948, Coulaud 1995
MIMOSACEAE	Acacia suaveolens (Smith) Willd.	*Australia		26	Morrison 1987
MIMOSACEAE	*Acacia verticillata* (L'Hérit.) Willd.	*unknown		26	Tijo 1948
MYRTACEAE	*Calytrix tetragona* Labill.	*unknown		22	Rye 1979
MYRTACEAE	*Eucalyptus amygdalina* Labill.	Tasmania	11		McAulay & Cruickshank 1937
MYRTACEAE	*Eucalyptus cordata* Labill.	Tasmania	11		McAulay & Cruickshank 1937
MYRTACEAE	*Eucalyptus dalrympleana* Maiden	*unknown		22	Ruggeri 1960
MYRTACEAE	*Eucalyptus globulus* Labill.	Tasmania	11a	22b	aMcAulay *et al.* 1936, bWD Jackson unpub
MYRTACEAE	*Eucalyptus gunnii* Hook.f.	Tasmania		22	Atchison 1947
MYRTACEAE	*Eucalyptus johnstonii* Maiden,	Tasmania	11		McAulay *et al* . 1936
MYRTACEAE	*Eucalyptus obliqua* L'Hérit	Tasmania	11		McAulay & Cruickshank 1937
MYRTACEAE	*Eucalyptus pauciflora* Sieber ex Sprengel	Tasmania	11		McAulay & Cruickshank 1937
MYRTACEAE	*Eucalyptus rubida* Deane & Maiden	Tasmania		22	Atchison 1947
MYRTACEAE	*Eucalyptus pulchella* Desf.	Tasmania	11a	22b	aMcAulay & Cruickshank 1937, bAtchison 1947
MYRTACEAE	*Eucalyptus urnigera* Hook.f.	Tasmania		22	Jackson unpub
MYRTACEAE	*Eucalyptus viminalis* Labill.	Tasmania	11a	22b	aMcAulay & Cruickshank 1937, bAtchison 1947
MYRTACEAE	*Leptospermum glaucescens* S.Schauer	*NZ		22	Dawson 1987
MYRTACEAE	*Leptospermum lanigerum* (Aiton) Smith	*NZ		22	Dawson 1987
MYRTACEAE	*Leptospermum rupestre* Hook.f.	*NZ		22	Dawson 1987
MYRTACEAE	*Leptospermum scoparium* Forst. & Forst.f. var. *eximium* B.L.Burtt	*NZ		22	Dawson 1987
	var. *scoparium*	*NZ		22	Dawson 1987
ONAGRACEAE	*Epilobium billardierianum* Sér. ex DC. subsp. *billardierianum*	*NZ	18	36	Hair 1977
	subsp. *cinereum* (A.Rich.) Raven & Engelhorn	*NZ	18	36	Hair 1977
ONAGRACEAE	*Epilobium fugitivum* Raven & Engelhorn	Tasmania		36	Hair 1977
	subsp. *intermedium* Raven & Engelhorn	*NZ		36	Hair 1977
ONAGRACEAE	*Epilobium gunnianum* Hausskn	*NZ		36	Hair 1977
ONAGRACEAE	*Epilobium hirtigerum* A.Cunn.	*NZ		36	Hair 1977
ONAGRACEAE	*Epilobium pallidiflorum* Sol. ex A.Cunn.	*NZ	18	36	Hair 1977
ONAGRACEAE	*Epilobium perpusillum* Hausknn.	Tasmania	18		Beuzenberg in West & Raven 1977
ONAGRACEAE	*Epilobium rotundifolium* Forst.f.,	*NZ	18	36	Hair 1977
ONAGRACEAE	*Epilobium sarmentaceum* Hausskn.	*NZ		36	Hair 1977
ONAGRACEAE	*Epilobium tasmanicum* Hausskn.	*NZ	18	36	Hair 1977
ONAGRACEAE	*Epilobium willisii* Raven & Engelhorn	*NZ		36	Hair 1977

Table 1 cont.

Family	Species	Locality	n	2n	Authority
ORCHIDACEAE	Calochilus robertsonii *Benth.*	*Australia		24	Peakall & James 1989
ORCHIDACEAE	*Microtis parviflora* R.Br.	*Australia		44	Beuzenberg in Bates 1984
ORCHIDACEAE	*Microtis unifolia* (Forst.f.) Rchb.f	*aNZ, bAustralia	22b	88a	aBeuzenberg in Bates 1984, bPeakall & James 1989
ORCHIDACEAE	*Pterostylis nutans* R.Br.	*Australia		42	Peakall & James 1989
ORCHIDACEAE	*Spiranthes australis* Lindley	*unknown		30	Vij et al. 1981
ORCHIDACEAE	*Thelymitra carnea* R.Br	*NZ		62	Molloy & Dawson 1998
ORCHIDACEAE	*Thelymitra cyanea* (Lindley) Benth	*NZ		40	Molloy & Dawson 1998
ORCHIDACEAE	*Thelymitra ixioides* Swartz	*aNZ, bAustralia		28	aMolloy & Dawson 1998, bDawson & Beuzenberg in Dawson 2000
ORCHIDACEAE	*Thelymitra malvina* M.A.Clem., D.L.Jones & Molloy	*NZ		26	Molloy & Dawson 1998
ORCHIDACEAE	*Thelymitra pauciflora* R.Br.	*NZ		26	Molloy & Dawson 1998
ORCHIDACEAE	*Townsonia viridis* (Hook.f.) Schlechter	*unknown			Kores 1995
ORCHIDACEAE	*Spiranthes australis* (R.Br.) Lindley	*India	15a, 16a	30b	a Mehra & Vij 1970, bVij & Shekhar 1983
OXALIDACEAE	*Oxalis magellanica* Forst.f.,	*aNZ, bNew Guinea	10a	10b	aBeuzenberg & Hair 1983, bBorgman 1964
PLANTAGINACEAE	*Plantago antarctica* Decne.	Interlaken		12	MJ Brown & WD Jackson in Love 1982 *(Brown 1002)*
PLANTAGINACEAE	*Plantago bellidioides* Decne. in DC.	Ordnance Pt		12	MJ Brown & WD Jackson in Love 1982 *(HO26421)*
PLANTAGINACEAE	*Plantago daltonii* Decne. in DC.	Tasmania		12	WD Jackson unpub
PLANTAGINACEAE	*Plantago debilis* R.Br.	Barbers Mine, Fingal		12	MJ Brown & WD Jackson in Love 1982 *(HO19563)*
PLANTAGINACEAE	*Plantago gaudichaudii* Barnéoud	*Australia		12, 24, 36	Briggs 1973
PLANTAGINACEAE	*Plantago glabrata* Hook.f., Hook.	Lake Augusta		24	MJ Brown & WD Jackson in Love 1982 *(Brown 1007)*
PLANTAGINACEAE	*Plantago glacialis* B.G.Briggs, Carolin & Pulley	*Australia		12	WD Jackson unpub, Briggs 1973
PLANTAGINACEAE	*Plantago gunnii* Hook.f., Hook.	Mt Projection		36	MJ Brown & WD Jackson in Love 1982 *(HO19558)*
PLANTAGINACEAE	*Plantago hispida* R.Br.	Tasmania		12	MJ Brown & WD Jackson in Love 1982 *(Brown 1004)*
PLANTAGINACEAE	*Plantago paradoxa* Hook.f., Hook.	Iris R, Middlesex Plains		48	MJ Brown & WD Jackson in Love 1982 *(HO19559)*
PLANTAGINACEAE	*Plantago tasmanica* Hook.f., Hook. var. *tasmanica*	aMiddlesex Plains, bProiection Bluff		12	aWD Jackson unpub *(3853)*, bMJ Brown & WD Jackson in Love 1982 *(Brown 1001)*
PLANTAGINACEAE	*Plantago triantha* Sprengel	Cox Bight, South Coast		12	MJ Brown & WD Jackson in Love 1982 *(HO19555)*
PLANTAGINACEAE	*Plantago varia* R.Br.	Mt Nelson		24	WD Jackson *(3852)* , MJ Brown & WD Jackson in Love 1982 *(HO19557)*
POACEAE	*Agrostis muelleriana* Vickery	*NZ	21		Beuzenberg & Hair 1983
POACEAE	*Austrofestuca littoralis* (Labill.) E.Alexeev	*NZ		28	Hair 1968, Beuzenberg & Hair 1983
POACEAE	*Deschampsia cespitosa* (L.) P.Beauv.	*cosmopolitan	13, 14	26, 28, 52	many in Dawson 2000
POACEAE	*Dichelachne crinita* (L.f.) Hook.f.	*NZ		70	Beuzenberg & Hair 1983
POACEAE	*Echinopogon ovatus* (Forst.f.) P.Beauv.,	*NZ	21		Beuzenberg & Hair 1983
POACEAE	*Ehrharta stipoides* Labill.	*aAustralia, bNZ		48	aParthasarathy 1939, bDawson & Beuzenberg 2000
POACEAE	*Elymus scaber* (R.Br.) A.Löve	*unknown		42	Lu 1993
POACEAE	*Hierochloe redolens* (Vahl) Roemer & Schultes	*Falkland Islands		56	Moore 1967
POACEAE	*Imperata cylindrica* (L.) Raeuschel	*unknown	10		Bir & Singh 1983
POACEAE	*Poa labillardierei* Steudel	*Australia		28, 56, 84	May & Campbell 1991
POACEAE	*Spinifex sericeus* R.Br.	*NZ		18	Hair & Beuzenberg 1966
POACEAE	*Themeda triandra* Forsskal	*South Africa		40, 50, 60, 100	Liebenberg *et al.* 1993
POACEAE	*Trisetum spicatum* (L.) Richter	*cosmopolitan	14	28	many in Dawson 2000
PODOCARPACEAE	*Lagarostrobos franklinii* (Hook.f.) Quinn	Tasmania	15a	30ab	aHair & Beuzenberg 1958a, bSundar Rao 1959
PODOCARPACEAE	*Microcachrys tetragona* (Hook.) Hook.f.	Tasmania	15a	30ab	aHair & Beuzenberg 1958a, bSundar Rao 1959
PODOCARPACEAE	*Microstrobos niphophilus* J.Garden & L.A.S.Johnson	Tasmania	13a	26ab	aHair & Beuzenberg 1958a, bSundar Rao 1959
PODOCARPACEAE	*Phyllocladus asplenifolius* (Labill.) Rich. ex Hook.f.	Tasmania		18	Sundar Rao 1959
PODOCARPACEAE	*Podocarpus lawrencei* Hook.f.	Tasmania		38	Sundar Rao 1959
POLYGONACEAE	*Muehlenbeckia axillaris* (Hook.f.) Endl.	*NZ	10	20	Beuzenberg & Hair 1983
POLYGONACEAE	*Persicaria hydropiper* (L.) Spach	*Bulgaria		20	Stoeva 1985
POLYGONACEAE	*Rumex brownii* Campdera	*unknown		40	Degraeve 1975
PORTULACACEAE	*Montia fontana* L. subsp. *chondrosperma* (Fenzl) Walters	*Morocco		20	Galland 1988
POTAMOGETONACEAE	*Potamogeton crispus* L	*India	13	26, 52	Ghosh & Bhattacharya 1980
POTAMOGETONACEAE	*Potamogeton pectinatus* L.	*cosmopolitan	39	42, 78, 86	many in Dawson 2000
PRIMULACEAE	*Samolus repens* (Forst. & Forst.f.) Pers.	*NZ	26		Hair & Beuzenberg 1959
PROTEACEAE	*Agastachys odorata* R.Br.	aFlorentine, Thumbs	13a	26	aVenkata Rao 1957, Wiltshire & Stace 1997
PROTEACEAE	*Banksia marginata* Cav.	Hobart	14		Venkata Rao 1957
PROTEACEAE	*Banksia serrata* L.f.	Botanical Gardens, Hobart.	14		Venkata Rao 1957
PROTEACEAE	*Bellendena montana* R.Br.	aMt Wellington, National Park, Guilford, bPine Lake, Central Plateau	5a	10	aVenkata Rao 1957, bWiltshire & Stace 1997
PROTEACEAE	*Cenarrhenes nitida* Labill.	aFlorentine, Thumbs, bHartz Mt	14ab	26c, 28a	aVenkata Rao 1957, bRamsay 1963, cWiltshire & Stace 1997
PROTEACEAE	*Conospermum hookeri* (Meisn.) E.M.Bennett	Tasmania		22	Venkata Rao 1957
PROTEACEAE	*Grevillea australis* R.Br.	Launceston	10		Venkata Rao 1957
PROTEACEAE	*Hakea lissosperma* R.Br.	Mt Wellington	10		Venkata Rao 1957

Table 1 cont.

Family	Species	Locality	n	2n	Authority
PROTEACEAE	*Hakea microcarpa* R.Br.	Florentine		20	Venkata Rao 1957
PROTEACEAE	*Lomatia polymorpha* R.Br.	Mt Wellington, National Park	11	22	Venkata Rao 1957
PROTEACEAE	*Lomatia tasmanica* W.M.Curtis	SW Tasmania		33	Lynch *et al.* 1998
PROTEACEAE	*Lomatia tinctoria* (Labill.) R.Br.	aMt Wellington, National Park, bTasman Peninsula	11a	22	Lynch *et al.* 1998
PROTEACEAE	*Orites acicularis* (R.Br.) Roemer & Schultes	Mt Wellington, National Park	14	28	Venkata Rao 1957
PROTEACEAE	*Orites diversifolia* R.Br.	aSnug Tiers, bHartz Mt	15a	28b, 30a	aVenkata Rao 1957, bWiltshire & Stace 1997
PROTEACEAE	*Orites milliganii* Meisn. in DC.	Thumbs	14		Venkata Rao 1957
PROTEACEAE	*Persoonia gunnii* Hook.f., Hook.	National Park	7		Venkata Rao 1957
PROTEACEAE	*Telopea truncata* (Labill.) R.Br.	Hobart	11	22	Venkata Rao 1957
RANUNCULACEAE	*Caltha phylloptera* A.W.Hill	Cradle Mt, Horse track to Plateau		48	WD Jackson unpub
RANUNCULACEAE	*Clematis aristata* R.Br. ex Ker Gawler	Watronchulus Hill, Neika	8		WD Jackson unpub *(3825)*
RANUNCULACEAE	*Clematis gentianoides* DC.	aMt Nelson (slopes)	8a	16b	aWD Jackson unpub *(3826)*, bGodley 1976
RANUNCULACEAE	*Clematis microphylla* DC.	Saxon Ck, Harford Rd	8		WD Jackson unpub *(3816)*
RANUNCULACEAE	*Ranunculus acaulis* Banks & Soland. ex DC.	Ocean Beach, Strahan		48	Menadue & Crowden 1985 *(HO88516)*
RANUNCULACEAE	*Ranunculus amphitrichus* Colenso	six locations		96	Menadue & Crowden 1985 *(HO88312)*
RANUNCULACEAE	*Ranunculus collicola* Menadue	Second Lagoon, Central Plateau		48	Menadue 1986 *(HO88749)*
RANUNCULACEAE	*Ranunculus collinus* R.Br. ex DC.	Mt Wellington (1300m)	24	48	Menadue 1986 *(HO88834)*
RANUNCULACEAE	*Ranunculus decurvus* (Hook.f.) Melville	aJericho, bPine Lake		16	WD Jackson unpub *(3836)*
		Arthurs Lakes	24	48	WD Jackson unpub *(3835)*
		Iris R., Cradle Mt.		16	Menadue & Crowden 1985 *(HO88516)*
RANUNCULACEAE	*Ranunculus glabrifolius* Hook.	aLagoon of Islands, bHazelwood Lag.	32a	48b	aW Jackson unpub *(3841)*, bMenadue & Crowden 1985 *(HO88874)*
RANUNCULACEAE	*Ranunculus gunnianus* Hook.	Pine Lake (bogs)	24a	48b	aWD Jackson unpub, bMenadue & Crowden 1985 *(HO88835)*
RANUNCULACEAE	*Ranunculus jugosus* Menadue	L. Augusta		48	bMenadue & Crowden 1985 *(HO81877)*
RANUNCULACEAE	*Ranunculus lappaceus* Smith in Rees	aMt Nelson (slopes), bQuoin Hill	8	16	aWD Jackson unpub *(3829)*, *bMenadue 1986 (HO88316)*
RANUNCULACEAE	*Ranunculus nanus* Hook.	aArthurs Lakes, bSecond Lagoon	8	16	aJackson unpub 3837, bMenadue & Crowden 1985 *(HO88314)*
RANUNCULACEAE	*Ranunculus pascuinus* (Hook.f.) Melville	aLagoon of Islands, bMiddlesex Plains, cBlackbog Ck., Cradle Mt Rd	8	16	WD Jackson unpub a*(3831)* ,b*(3832*), cbMenadue & Crowden 1985 *(HO88517)*
RANUNCULACEAE	*Ranunculus pimpinellifolius* Hook.	aBarren Tier Marsh, bClarence Weir	8	16	aWD Jackson unpub (3830), bbMenadue & Crowden 1985 *(HO88841)*
RANUNCULACEAE	*Ranunculus prasinus* Menadue	Whites Lag., Tunbridge		48	Menadue & Crowden 1985 *(HO88842)*
RANUNCULACEAE	*Ranunculus pumilio* R.Br. ex DC.	Brownwater Lag., L. Crescent		14	bMenadue & Crowden 1985 *(HO88518)*
RANUNCULACEAE	*Ranunculus scapiger* Hook.	aMt Wellington (1000m), bClarence Weir	8	16	aWD Jackson unpub *(3833)*, bMenadue & Crowden 1985 *(HO88845)*
RANUNCULACEAE	*Ranunculus sessiliflorus* R.Br. ex DC.	Geilston Bay		14	Menadue & Crowden 1985 *(HO88840)*
RANUNCULACEAE	*Ranunculus setaceus* Rodway	aPine L. (margin), bBen Lomond Plateau		16	aWD Jackson unpub *(3801)*, bMenadue & Crowden 1985 *(HO88306)*
RANUNCULACEAE	*Ranunculus triplodontus* Melville	aArthurs Lakes, bL. Augusta	24a	48ab	aWD Jackson unpub *(3838)*, bMenadue 1986 *(HO88837)*
RESTIONACEAE	*Baloskion tetraphyllum* (Labill.) B.G.Briggs &	Strahan		22	Briggs 1966
RESTIONACEAE	*Empodisma minus* (Hook.f.) L.A.S.Johnson &	*Australia		24	BG Briggs in Johnson & Cutler 1973
RESTIONACEAE	*Hypolaena fastigiata* R.Br.	*Australia		66	Briggs 1966
RESTIONACEAE	*Leptocarpus tenax* (Labill.) R.Br.	*Australia		22	Briggs 1966
RESTIONACEAE	*Sporadanthus tasmanicus* (Hook.f.) B.G.Briggs & L.A.S.Johnson	Navarre R. to King William Ra.		18	Briggs 1966
RHAMNACEAE	*Pomaderris apetala* Labill. subsp. *maritima* N.G.Walsh & F.Coates	*NZ		36	Hair 1963
RHAMNACEAE	*Pomaderris aspera* Sieber ex DC.	*NZ	12	24	Harvey & Rattenbury 1985
ROSACEAE	*Acaena novae-zelandiae* Kirk	*aNZ, bAustralia	21a	42b	aDawson 1960, bMoore 1964
ROSACEAE	*Acaena pallida* (Kirk) Allan	*NZ	21		Dawson 1960
ROSACEAE	*Geum urbanum* L.	*Britain		42	Wentworth *et al.* 1991
RUBIACEAE	*Coprosma moorei* Rodway	*unknown		*44*	Beuzenberg 1983
RUBIACEAE	*Coprosma pumila* Hook.f.	Tasmania		c. 220	Dawson 1995
RUBIACEAE	*Coprosma perpusilla* Colenso subsp. *perpusilla*	*NZ		132	Beuzenberg 1983
RUBIACEAE	*Nertera granadensis* (L.f.) Druce	*NZ		22	Hair 1963
RUTACEAE	*Acradenia frankliniae* Milligan ex Kippist	Corinna, Pieman R.		38	WD Jackson unpub *(2312)*
RUTACEAE	*Boronia anemonifolia* A.Cunn. in Field	*Australia	18		Smith-White 1954
RUTACEAE	*Boronia nana* Hook.	*Australia	18		Stace & Armstrong 1992
RUTACEAE	*Boronia parviflora* Smith	*Australia	9	18	Smith-White 1954
RUTACEAE	*Boronia pilosa* Labill.	*Australia	11		Smith-White 1954

Table 1 cont.

Family	Species	Locality	n	2n	Authority
RUTACEAE	*Correa alba* Andrews	aClifton Beach, *bAustralia	16b	32a	aWD Jackson unpub (2416), bSmith-White1954
RUTACEAE	*Correa backhouseana* Hook.	Tasmania		32	WD Jackson unpub *(2457)*
RUTACEAE	*Correa lawrenceana* Hook.	*Australia	16		Smith-White 1954
RUTACEAE	*Nematolepis squamea* (Labill.) Paul G.Wilson	National Park	16		Smith-White 1954
RUTACEAE	*Philotheca virgata* (Hook.f.) Paul G.Wilson	*Australia		c. 28	Stace & Armstrong 1992
RUTACEAE	*Zieria littoralis* J.A.Armstrong	*Australia	36ab	72a	aStace & Armstrong 1992, bSmith-White 1954
RUTACEAE	*Zieria veronicea* (F.Muell.) Benth.	*Australia	18	36	Stace & Armstrong 1992
SAPINDACEAE	*Dodonaea viscosa* Jacq.	*NZ	14	28	Hair & Beuzenberg 1959
SAPINDACEAE	subsp. *spatulata* (Smith) J.West	*Australia	14		West 1984
SCROPHULARIACEAE	*Chionohebe ciliolata* (Hook.f.) B.G.Briggs & Ehrend.	*NZ		42	Hair 1970
SCROPHULARIACEAE	*Euphrasia collina* R.Br.?	*Australia	54-70	60-70	Barker *et al.* 1988
SCROPHULARIACEAE	*Euphrasia gibbsiae* Du Rietz ?	*Australia		132	Barker *et al.* 1988
SCROPHULARIACEAE	*Glossostigma elatinoides* (Benth.) Benth. ex Hook.f.	*NZ	5	10	Beuzenberg & Hair 1983
SCROPHULARIACEAE	*Gratiola nana* Benth. in DC.	*NZ	15		Hair *et al.* 1967
SCROPHULARIACEAE	*Limosella australis* R.Br.	*NZ	30		Hair & Beuzenberg 1960
SCROPHULARIACEAE	*Mazus pumilio* R.Br.	*NZ	52		Hair & Beuzenberg 1960
SCROPHULARIACEAE	*Mimulus repens* R.Br.	*NZ		20	Hair & Beuzenberg 1959
SOLANACEAE	*Solanum laciniatum* Aiton	*acNZ, bAustralia	46ab	92c, 96d	aBaylis 1954, b1963, cGerasimenko & Reznikova 1968, d Beuzenberg & Hair 1983
STACKHOUSIACEAE	*Stackhousia gunnii* Hook.f.	Tunbridge	10		WD Jackson unpub *(2568)*
STACKHOUSIACEAE	*Stackhousia monogyna* Labill.	aMt Nelson, b*unknown	10a, 9,15b		aWD Jackson unpub *(3879)*, bTurner 1966
STACKHOUSIACEAE	*Stackhousia viminea* Smith in Rees	Pieman R Heads	10		WD Jackson unpub *(2572)*
STYLIDIACEAE	*Stylidium armeria* (Labill.) Labill.	Port Davey	30		Jackson and Wiltshire 2001, WD Jackson unpub *(3812)*
STYLIDIACEAE	*Stylidium dilatatum* W.D.Jackson & R.J.E.Wiltshire	Waterworks, Hobart	30	60	Jackson and Wiltshire 2001, WD Jackson unpub *(3805)*
STYLIDIACEAE	*Stylidium graminifolium* Swartz ex Willd.	Proctors Rd	15	30	Jackson and Wiltshire 2001, WD Jackson unpub *(3802)*
THYMELAEACEAE	*Kelleria dieffenbachii* (Hook.) Endl.	*NZ		18	Dawson 1989
THYMELAEACEAE	*Pimelea cinerea* R.Br.	Neika, Mt Wellington		36	Cruickshank 1953
THYMELAEACEAE	*Pimelea curviflora* R.Br.	Dunorlan, Launceston		36	Cruickshank 1953
THYMELAEACEAE	*Pimelea drupacea* Labill.	Taranna, Hobart		108	Cruickshank 1953
THYMELAEACEAE	*Pimelea flava* R.Br.	Glenorchy, Murdunna		36	Cruickshank 1953
THYMELAEACEAE	*Pimelea glauca* R.Br.	Triabunna		36	Cruickshank 1953
THYMELAEACEAE	*Pimelea humilis* R.Br.	Campania, Glenorchy, Sandy Bay		72	Cruickshank 1953
THYMELAEACEAE	*Pimelea ligustrina* Labill.	Mt Lloyd		36	Cruickshank 1953
THYMELAEACEAE	*Pimelea linifolia* Smith	Hastings		90	Cruickshank 1953
THYMELAEACEAE	*Pimelea nivea* Labill.	Collinsvale, Glenorchy, Sandy Bay		36	Cruickshank 1953
THYMELAEACEAE	*Pimelea pauciflora* R.Br.	Dunorlan, Launceston		36	Cruickshank 1953
THYMELAEACEAE	*Pimelea pygmaea* F.Muell. & C.Stuart ex Meisn.	James R., L Augusta		36	Cruickshank 1953
THYMELAEACEAE	*Pimelea sericea* R.Br.	Mt Arthur		36	Cruickshank 1953
THYMELAEACEAE	*Pimelea serpyllifolia* R.Br.	King I		36	Cruickshank 1953
TYPHACEAE	*Typha domingensis* Pers.	*Australia		30	Finlayson *et al.* 1985
TYPHACEAE	*Typha orientalis* C.Presl	*aNZ, bAustralia	30a	60	aHair *et al.* 1967, bFinlayson *et al.* 1985
URTICACEAE	*Australina pusilla* (Desf. ex Poiret) Gaudich.	*NZ	12	24	Beuzenberg & Hair 1960
URTICACEAE	*Parietaria debilis* Forst.f.	*aJuan Fernandez Islands, bArgentina	8a	16b	aSun *et al.* 1990, bFernadez *et al.* 1990
VIOLACEAE	*Hymenanthera dentata* R.Br. ex DC	*NZ		64	Dawson 1995
VIOLACEAE	*Viola cunninghamii* Hook.f.	*NZ	12	24	Hair & Beuzenberg 1960
WINTERACEAE	*Tasmannia lanceolata* (Poiret) A.C.Smith dwarf form	Mt Wellington (1300m)	13a	28b, 26c	aWD Jackson unpub *(3869)*, bHF Gulline unpub (probably incorrect), cS Smith-White in Darlington & Wylie 1955
	tree form	Guilford Junction	13a	26b	aWD Jackson unpub *(3870)*, bRaven & Kyhos 1965
XANTHORRHOEACEAE	*Lomandra longifolia* Labill.	Proctors Rd	16a	16b,32ab	aWD Jackson unpub *(3823)*, bBriggs 1986
XANTHORRHOEACEAE	*Lomandra nana* (A.Lee) A.Lee	aRichmond,*b unknown	7a	14a,28b	aWD Jackson unpub *(3821)*, bBriggs 1986
XANTHORRHOEACEAE	*Xanthorrhoea arenaria* Bedford	Waterhouse Pt	**11**	**22**	WD Jackson unpub *(3864)*
XANTHORRHOEACEAE	*Xanthorrhoea australis* R.Br.	aGrasstree Hill, *bAustralia	11	22	aWD Jackson unpub *(3863)*, bBriggs 1966
XYRIDACEAE	*Xyris gracilis* R.Br.	*Australia		26	Briggs 1966
XYRIDACEAE	*Xyris muelleri* Malme	Tullah		26	Briggs 1966
XYRIDACEAE	*Xyris operculata* Labill.	W. Montagu	13	26	Briggs 1966
ZANNICHELLIACEAE	*Lepilaena bilocularis* Kirk	*NZ		12	Hair *et al.* 1967

TABLE 2
Proportion of indigenous Tasmanian spermatophyte species with reported chromosome numbers in each family

	No. Genera	No. Species	Tasmanian counts	Other provenance counts	Total	%	Polyploidy	Variation between genera	Variation between species	Variation within species
AIZOACEAE (FICOIDEAE)	3	4		1	1	25	*	*	*	
ALISMATACEAE	1	1			0	0				
AMARANTHACEAE	3	3			0	0				
APIACEAE (UMBELLIFERAE)	14	39		5	5	13	*	*	*	
APOCYNACEAE	2	2			0	0				
ARALIACEAE	2	2			0	0	*	*		
ASTERACEAE (COMPOSITAE)	47	184	3	44	47	26	*	*	*	*
BIGNONIACEAE	1	1			0	0				
BORAGINACEAE	3	3			0	0		*	*	
BRASSICACEAE (CRUCIFERAE)	8	20		2	2	10	*	*	*	
BRUNONIACEAE	1	1	1		1	100				
BURMANNIACEAE	1	1			0	0				
CALLITRICHACEAE	1	3			0	0	*	*	*	
CAMPANULACEAE	4	16	5	10	15	94	*	*	*	*
CAPRIFOLIACEAE	1	1			0	0				
CARYOPHYLLACEAE	8	15		4	4	27	*	*		
CASUARINACEAE	1	7	3	1	4	57	*		*	*
CENTROLEPIDACEAE	3	13	1		1	8				
CHENOPODIACEAE	9	13		3	3	23	*			
CLUSIACEAE (GUTTIFERAE, HYPERICACEAE)	1	2		2	2	100				
CONVOLVULACEAE	4	7		3	3	43		*		
CRASSULACEAE	1	7		2	2	29	*		*	
CUCURBITACEAE	1	1			0	0				
CUNONIACEAE	2	2		1	1	50		*		
CUPRESSACEAE	3	6	6		6	100				
CUSCUTACEAE	1	1			0	0				
CYMODOCEACEAE	1	1			0	0				
CYPERACEAE	18	119	1	14	15	13	*	*	*	*
DILLENIACEAE	1	14			0	0				
DONATIACEAE	1	1			0	0				
DROSERACEAE	1	7		5	5	71	*		*	*
ELAEOCARPACEAE	2	2			0	0		*		
ELATINACEAE	1	1			0	0				
EPACRIDACEAE	17	89	12	18	30	34	*	*	*	*
ERICACEAE	1	4	1	2	3	75				
ESCALLONIACEAE	2	2			0	0	*	*		
EUCRYPHIACEAE	1	2			0	0				
EUPHORBIACEAE	10	13			0	0	*	*		
FABACEAE (LEGUMINOSAE)	25	53	4	4	8	15	*	*	*	*
FAGACEAE (NOTHOFAGACEAE)	1	2	1		1	50				
FRANKENIACEAE	1	1			0	0				
GENTIANACEAE	2	10			0	0				
GERANIACEAE	2	7		3	3	43	*	*	*	*
GOODENIACEAE	5	12	9		9	75	*	*		*
GUNNERACEAE	1	1			0	0				
GYROSTEMONACEAE	1	1			0	0				
HAEMODORACEAE	1	1			0	0				
HALORAGACEAE	3	18		1	1	6		*		
HYDATELLACEAE	2	2			0	0				
HYDROCHARITACEAE	2	2		1	1	50				
IRIDACEAE	4	6	2	3	5	83	*	*	*	
JUNCACEAE	2	33		6	6	18	*	*	*	*
JUNCAGINACEAE	1	7		2	2	29	*		*	*
LAMIACEAE (LABIATAE)	7	10			0	0	*	*		
LAURACEAE	1	4			0	0	*	*		
LEMNACEAE	2	3		3	3	100	*			*
LENTIBULARIACEAE	1	6			0	0				
LILIACEAE	19	38	16	1	17	45	*	*	*	*
LINACEAE	1	2			0	0				
LOGANIACEAE	3	6			0	0				

Table 2 cont.

	No. Genera	No. Species	Tasmanian counts	Other provenance counts	Total	%	Polyploidy	Variation between genera	Variation between species	Variation within species
LYTHRACEAE	1	2		2	2	100	*		*	
MALVACEAE	4	4			0	0	*	*		
MENYANTHACEAE	2	4			0	0				
MIMOSACEAE	1	20		4	4	20				
MONIMIACEAE	2	2			0	0	*	*		
MYOPORACEAE	1	2			0	0				
MYRTACEAE	9	51	11	6	17	33				
OLEACEAE	2	1			0	0				
ONAGRACEAE	1	10	2	8	10	100				
ORCHIDACEAE	39	196		11	11	6	*	*	*	
OXALIDACEAE	1	4		1	1	25				
PITTOSPORACEAE	4	6			0	0				
PLANTAGINACEAE	1	13	11	2	13	100	*		*	*
PLUMBAGINACEAE	1	2			0	0				
POACEAE (GRAMINEAE)	45	126		13	13	10	*	*	*	*
PODOCARPACEAE	5	5	5		5	100		*	*	
POLYGALACEAE	1	5			0	0				
POLYGONACEAE	3	10		3	3	30	*	*		
PORTULACACEAE	4	6		1	1	17	*	*		
POSIDONIACEAE	1	1			0	0				
POTAMOGETONACEAE	1	6		2	2	33	*		*	
PRIMULACEAE	1	1		1	1	100				
PROTEACEAE	11	28	17		17	61	*	*	*	*
RANUNCULACEAE	4	23	22		22	96	*	*	*	*
RESTIONACEAE	10	14	2	3	5	36	*	*		
RHAMNACEAE	5	23		2	2	9	*	*	*	
ROSACEAE	4	12		3	3	25	*	*	*	*
RUBIACEAE	5	18	1	3	4	22	*	*	*	
RUPPIACEAE	1	3			0	0				
RUTACEAE	8	22	4	8	12	55	*	*	*	
SANTALACEAE	2	7			0	0				
SAPINDACEAE	1	2		2	2	100		*		
SCROPHULARIACEAE	10	24		8	8	33	*	*	*	*
SOLANACEAE	2	4		1	1	25	*			*
STACKHOUSIACEAE	1	5	3		3	60				
STERCULIACEAE	1	4			0	0				
STYLIDIACEAE	3	8	3		3	38	*	*	*	
THYMELAEACEAE	2	19	13	1	14	74	*	*	*	*
TREMANDRACEAE	1	5			0	0				
TYPHACEAE	1	4		2	2	50	*		*	
URTICACEAE	3	4		2	2	50		*		
VIOLACEAE	2	7		2	2	29	*	*	*	
WINTERACEAE	1	1	1		1	100				
XANTHORRHOEACEAE	2	5	4		4	80	*	*	*	*
XYRIDACEAE	1	5	2	1	3	60				
ZANNICHELLIACEAE	1	6		1	1	17	*	*		
ZOSTERACEAE	2	2			0	0				
ZYGOPHYLLACEAE	1	1			0	0				
Total 108 families	484	1568	166	234	400	26	50	47	36	22
			11%	15%	26%		46%	44%	33%	20%

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REFERENCES

ADAMS, L.G., 1979: A review of the genus *Solenogyne* (Asteraceae) in Australia and New Zealand. *Brunonia* 2: 43–66.

ARMSTRONG, J.M., 1964: *Cytological Studies in some New Zealand Plants.* Unpub. M.Sc. thesis, University of Otago, Dunedin, New Zealand: 94 pp.

AROHONKA, T., 1982: Chromosome counts of vascular plants of the island Seili in Nauvo, southwestern Finland. *Turun Yliopiston Julkaisuja : Sarja A II, Biologia-Geographica* 3: 1–12.

ATCHISON, E., 1947: Chromosome numbers in the Myrtaceae. *American Journal of Botany* 34: 159–164.

BARKER, W.R., KIEHN, M. & VITEK, E., 1988: Chromosome numbers in Australian *Euphrasia* (Scrophulariaceae) *Plant Systematics & Evolution* 158: 161–164.

BARLOW, B.A., 1958: Diploid and tetraploid *Casuarina littoralis* Salisb. (syn. *C. suberosa* Ott. & Dietr.). *Australian Journal of Bo*tany 6: 38–46.

BARLOW, B.A., 1959: Chromosome numbers in the Casuarinaceae. *Australian Journal of Botany* 7: 230–237.

BATES, R., 1984: The genus *Microtis* R.Br. (Orchidaceae): A taxonomic revision with notes on biology. *Journal of the Adelaide Botanical Gardens* 7: 45–89.

BAYLIS, G.T.S., 1954: Chromosome number and distribution of *Solanum aviculare* Forst. and *S. laciniatum* Ait. *Transactions of the Royal Society of New Zealand* 82: 639–643.

BELL, C.R. & CONSTANCE, L., 1966: Chromosome numbers in Umbelliferae. III. *American Journal of Botany* 53: 512–520.

BEUZENBERG, E.J., 1975: Contributions to a chromosome atlas of the New Zealand flora – 17. *Senecio* (Compositae). *New Zealand Journal of Botany* 13: 345–353.

BEUZENBERG, E.J. & HAIR, J.B., 1963: Contributions to a chromosome atlas of the New Zealand flora – 5. Miscellaneous families. *New Zealand Journal of Botany* 1: 53–67.

BEUZENBERG, E.J. & HAIR, J.B., 1983: Contributions to a chromosome atlas of the New Zealand flora – 25. Miscellaneous species. *New Zealand Journal of Botany* 21: 13–20.

BEUZENBERG, E.J. & HAIR, J.B., 1984: Contributions to a chromosome atlas of the New Zealand flora – 27. Compositae. *New Zealand Journal of Botany* 22: 353–356.

BEUZENBERG, E.J. & GROVES, B.E., 1974: Contributions to a chromosome atlas of the New Zealand flora – 16. Miscellaneous families. *New Zealand Journal of Botany* 12: 211–217.

BIR, S. S. & C. SINGH, C., 1983: SOCGI plant chromosome number reports – I. *Journal of Cytology & Genetics* 18: 60–61.

BORGMAN, E., 1964: Anteil der Polyploiden in der Flora des Bismarksgebirges von Ostneuguinea. *Zeitschrift für Botanik* 52: 118–172.

BRIGGS, B.G., 1966: Chromosome numbers in some Australian monocotyledons. *Contributions to the New South Wales National Herbarium* 4: 24–34.

BRIGGS, B.G., 1970: Chromosome numbers in some Australian species of *Eleocharis* (Cyperaceae). *Contributions to the New South Wales National Herbarium* 4: 130–136.

BRIGGS, B.G., 1973: Chromosomal studies on *Plantago* in Australia. *Contributions to the New South Wales National Herbarium* 4: 399–405.

BRIGGS, B.G., 1986: Chromosome numbers in *Lomandra* (Dasypogonaceae). *Telopea* 2: 741–744.

BROWN, M.J., 1979: *Studies of variation in some Tasmanian species of* Plantago *L.* Unpub. Ph.D. thesis, University of Tasmania, Hobart.

BROWN, M.J. & JACKSON, W.D., 1982: *In* Löve, A. (Ed.): IOPB chromosome number reports LXXV. *Taxon* 31: 342–368.

BUCHANAN, A.M., 2002. A Census of the Vascular Plants of Tasmania, online edn. *Tasmanian Herbarium Occasional Publication No. 6.* Retrieved 30 October 2002, from http://www.tmag.tas.gov.au/Herbarium/TasVascPlants.pdf.

CALLAN, H.G., 1941: The cytology of *Gaulthettya wisleyensis* (Marchant) Rehder: a new mode of species formation. *Annals of Botany* 5: 579–585.

CHINNAPPA, C.C. & CHMIELEWSKI, J.G., 1987: Documented plant chromosome numbers 1987: 1. Miscellaneous counts from western North America. *Sida* 12: 409–417.

COLLET, C. & WESTERMAN, M., 1987: Interspecies comparison of the highly–repeated DNA of Australasian *Luzula* (Juncaceae). *Genetica* 74: 95–103.

COPE, T. A. & STACE, C. A., 1985: Cytology and hybridization in the *Juncus bufonius* L. aggregate in western Europe *Watsonia* 15: 309—320.

COULAUD, J., BROWN, S.C. & SILJAK–YAKOVLEV, S., 1995: First cytogenetic investigation in populations of *Acacia heterophylla,* endemic from La Reunion Island, with reference to *A. melanoxylon. Annals of Botany* 75: 95–100.

CRUICKSHANK, R.H., 1953: Chromosome numbers in the genus *Pimelea. Papers and Proceedings of the Royal Society of Tasmania* 87: 13–16.

CURTIS, W.M., 1952: Variation in certain Tasmanian plants. *New Phytologist* 51: 398.

DARLINGTON, C.D. & WYLIE, A.P., 1955: *Chromosome atlas of flowering plants.* 2nd edn. Allen & Unwin, London.

DAVIS, G.L., 1962: Embryological studies in the Compositae. I. Sporogenesis, gametogenesis, and embryogeny in *Cotula australis* (Less.) Hook.f. *Australian Journal of Botany* 10: 1–12.

DAWSON, M., 1960: Natural *Acaena* hybrids in the vicinity of Wellington. *Transactions of the Royal Society of New Zealand* 88: 13–27.

DAWSON, M., 1987 Contributions to a chromosome atlas of the New Zealand flora – 29. Myrtaceae. *New Zealand Journal of Botany* 25: 367–369.

DAWSON, M., 1990: *Leptospermum scoparium* (manuka) – chromosome variation of cultivars. *Horticulture in N.Z.* 1 (2): 15–19.

DAWSON, M. I., 1995: Contributions to a chromosome atlas of the New Zealand flora–34. Miscellaneous species. *New Zealand Journal of Botany* 33: 477–487.

DAWSON, M., 2000: Index of chromosome numbers of indigenous New Zealand spermatophytes. *New Zealand Journal of Botany* 38: 47–150.

DAWSON, M.I. & BEUZENBERG, E.J., 2000: Contributions to a chromosome atlas of the New Zealand flora – 36. Miscellaneous families. *New Zealand Journal of Botany* 38: 1–23.

DEGRAEVE, N., 1975: Contribution à l'étude cytotaxonomique des *Rumex.* I. Le genre *Rumex* L. *sensu stricto. Caryologia* 28: 187–201.

DE LANGE, P.J., MURRAY, B.J. & CROWCROFT, G.M., 1997: Chromosome numbers of New Zealand specimens of *Atriplex billardierei,* Chenopodiaceae. *New Zealand Journal of Botany* 35: 129–131.

DE LANGE, P.J., MURRAY, B.J., GARDNER, R.O. & CROWCROFT, G.M., 1998: *Atriplex cinerea* (Chenopodiaceae) in New Zealand. *New Zealand Journal of Botany* 36: 521–529.

FERNÁNDEZ, A.M.F.DE, DE CANELADA, M.E.L., DE GARCIA, M.S.C., WURSCHMIDT, A., 1990: Cromosomas de Urticáceas Argentines. *Lilloa* 37: 97–98.

FINLAYSON, M., FORRESTER, R.I., MITCHELL, D.S. & CHICK, A.J., 1985: Identification of native *Typha* species in Australia. *Australian Journal of Botany* 33: 101–107.

GALLAND, N., 1988: Recherche sur l'origine de la flore orophile du Maroc étude caryologique et cytogéographique. *Travaux de l'Institut Scientifique, Université Mohammed V. Série Botanique* 35: 1–168.

GHOSH, D. K. & BHATTACHARYA, G. N., 1980: Chromosomes in some species of *Potamogeton* and *Aponogeton. Bulletin of the Botanical Society of Bengal* 34: 83–88.

GODLEY, E.J., 1976: Sex ratio in *Clematis gentianoides* DC. *New Zealand Journal of Botany* 14: 299–306.

GOLDBLATT, P., 1979: Preliminary cytology of Australasian Iridaceae. *Annals of the Missouri Botanical Gardens* 66: 851–855.

GROVES, B.E., 1977: Contributions to a chromosome atlas of the New Zealand flora – 19. Gnaphalium (Compositae). *New Zealand Journal of Botany* 15: 17–18.

GROVES, B.E. & HAIR, J.B., 1971: Contributions to a chromosome atlas of the New Zealand flora – 15. Miscellaneous families. *New Zealand Journal of Botany* 9: 569–575.

GULLINE, H.F., 1952: The cytology of *Athrotaxis. Papers and Proceedings of the Royal Society of Tasmania* 86: 131–136.

GUPTA, R. C. & GILL, B. S., 1981: *In* Löve, Á. (Ed.): IOPB Chromosome number reports LXXI. *Taxon* 30: 514.

GUPTA, R. C. & GILL, B. S., 1989: Cytopalynology of north and central Indian Compositae. *Journal of Cytological Genetics* 24: 96–105.

HAIR, J.B., 1962: Basic chromosome numbers in *Cotula. Chromosome Information Service* 3: 41–42.

HAIR, J.B., 1963: Contributions to a chromosome atlas of the New Zealand flora – 6. Miscellaneous families. *New Zealand Journal of Botany* 1: 243–257.

HAIR, J.B., 1977: Contributions to a chromosome atlas of the New Zealand flora – 18. *Epilobium* (Onagraceae). *New Zealand Journal of Botany* 15: 5–15.

HAIR, J.B., 1980: Contributions to a chromosome atlas of the New Zealand flora – 20. *Celmisia* and *Damnamenia* (Compositae). *New Zealand Journal of Botany* 18: 553–558.

HAIR, J.B., 1980a: Contributions to a chromosome atlas of the New Zealand flora – 21. Umbelliferae (miscellaneous genera). *New Zealand Journal of Botany* 18: 559–562.

HAIR, J.B., 1983: Contributions to a chromosome atlas of the New Zealand flora – 23. *Ranunculus* (Ranunculaceae). *New Zealand Journal of Botany* 21: 3–7.

HAIR, J.B. & BEUZENBERG, E.J., 1958a: Chromosomal evolution of the Podocarpaceae. *Nature* 181: 1584–1586.

HAIR, J.B. & BEUZENBERG, E.J., 1958b: Contributions to a chromosome atlas of the New Zealand flora – I. *New Zealand Journal of Science* 1: 617–628.

HAIR, J.B. & BEUZENBERG, E.J., 1959: Contributions to a chromosome atlas of the New Zealand flora – 2. Miscellaneous families. *New Zealand Journal of Science* 2: 148–156.

HAIR, J.B. & BEUZENBERG, E.J., 1960: Contributions to a chromosome atlas of the New Zealand flora – 4. Miscellaneous families. *New Zealand Journal of Science* 3: 432–440.

HAIR, J.B. & BEUZENBERG, E.J., 1966: Contributions to a chromosome atlas of the New Zealand flora – 7. Miscellaneous families. *New Zealand Journal of Botany* 4: 255–266.

HAIR, J.B., BEUZENBERG, E.J. & Pearson, B., 1967: Contributions to a chromosome atlas of the New Zealand flora – 9. Miscellaneous families. *New Zealand Journal of Botany* 5: 185–196.

HALVANKAR, G.B. & PATIL, V.P., 1990: Inter–specific variation in the karyotypes of the genus *Glycine* Willd. *Cytologia* 55: 273—279.

HAMAL, I.A., LANGER, A. & KOUL, A.K., 1986: Nucleolar organizing region in the Apiaceae (Umbelliferae). *Plant Systematics & Evolution* 154: 11–30

HARRIMAN, N.A., 1981: *In* Löve, Á. (Ed.): IOPB Chromosome number reports LXXI. *Taxon* 30: 508–519.

HARVEY, C.F. & RATTENBURY, J.A., 1985: Microsporogenesis and pollen viability in New Zealand taxa of *Pomaderris* Labill. (Rhamnaceae). *New Zealand Journal of Botany* 23: 321–330.

HOLZAPFEL, S., 1994: A revision of the genus *Picris* (Asteraceae, Lactuceae) s.l. in Australia. *Willdenowia* 24: 97–218.

HSU, C.–C., 1968: Preliminary chromosome studies on the vascular plants of Taiwan 2. *Taiwania* 14: 11–27.

HUGHES, J. & RICHARDS, A. J., 1988: The genetic structure of populations of sexual and asexual *Taraxacum* (dandelions). *Heredity* 60: 161–171.

JACKSON, W.D., 1958: Chromosome numbers in the Goodeniaceae and Brunoniaceae. *Papers and Proceedings of the Royal Society of Tasmania* 92: 161–163.

JACKSON, W.D. & Wiltshire, R.J.E., 2001: Historical taxonomy and a resolution of the *Stylidium graminifolium* complex (Stylidiaceae) in Tasmania. *Australian Systematic Botany* 14: 937–969.

JOHNSON, L.A.S. & CUTLER, D.F., 1973: *Empodisma*: a new genus of Australasian Restionaceae. *Kew Bulletin* 28: 381–385.

JOHNSON, M.A.T., 1993: *In* Mathew, B. *Sternbergia pulchella. Garden (London 1975+)* 118(1): 36–37.

KEIL, D.J., 1981: *In* Löve, Á. (Ed.): IOPB Chromosome number reports LXXXII. *Taxon* 30: 705–706.

KONDO, K., 1969: Chromosome numbers of carnivorous plants. *Bulletin of the Torrey Botanical Club* 96: 322–328.

KONDO, K. & OLIVER, M.C., 1979: Chromosome numbers of four species of *Drosera* (Droseraceae). *Annals of the Missouri Botanical Gardens* 66: 584–587.

KONDO, K. & LAVARACK, P.V., 1984: A cytotaxonomic study of some Australian species of *Drosera* L. (Droseraceae). *Botanical Journal of the Linnaean Society* 88: 317—333.

KORES, P.J., 1995: A systematic study of the genus *Acianthus* (Orchidaceae: Diurideae). *Allertonia* 7(3): 87–220.

KUMARI, S., SAGGOO, M.I.S. & KUMAR, S., 1989: SOCGI plant chromosome number reports – VIII. *Journal of Cytology and Genetics* 24: 179–183.

LABADIE, J., 1976: *Contribution à l'etude caryosystematique des especes halophiles du littoral languedocier (plus precisement, especes appartenant a la classe des Salicornietae).* Unpub. thesis, University of Languedoc, 222 pp.

LACKEY, J.A., 1980: Chromosome numbers in the Phaseoleae (Fabaceae: Faboideae) and their relation to taxonomy. *American Journal of Botany* 67: 595–602.

LARSEN, K., 1966: Studies in the flora of Thailand 40. Cytology of vascular plants. II. *Dansk. Botanisk Arkiv* 23: 375–399.

LAWRENCE, M.E., 1980: *Senecio* L. (Asteraceae) in Australia: chromosome numbers and the occurrence of polyploidy. *Australian Journal of Botany* 28: 151–166.

LAWRENCE, M.E., 1985: *Senecio* L. (Asteraceae) in Australia: recombination systems of a polyploid series. *Australian Journal of Botany* 33: 209–219.

LEE, A.T., 1966: Xanthorrhoeaceae. *Contributions to the New South Wales National Herbarium, Flora Series* 34: 1–42.

LIEBENBERG, H., LUBBINGE, L. & FOSSEY, A., 1993: Cytotaxonomic studies in *Themeda triandra* Forssk.: IV. A population cytogenetic study of a contact zone between tetraploid and hexaploid populations. *South African Journal of Botany* 59(3): 305–310.

LÖVE, Á. & LÖVE, D., 1980: *In* Löve, Á. (Ed.): IOPB Chromosome number reports LXIX. *Taxon* 29: 707–709.

LÖVE, Á. & LÖVE, D., 1981: *In* Löve, Á. (Ed.): IOPB Chromosome number reports LXXIII. *Taxon* 30: 829–861.

LU, B.–R., 1993: Meiotic studies of *Elymus nutans* and *E. jacquemontii* (Poaceae, Triticeae) and their hybrids with *Pseudoroegneria spicata* and seventeen *Elymus* species. *Plant Systematics & Evolution* 186: 193– 212.

LYNCH, A.J.J., BARNES, R.W., CAMBECÈDES, J. & VAILLANCOURT, R.E., 1998: Genetic evidence that *Lomatia tasmanica* (Proteaceae) is an ancient clone. *Australian Journal of Botany* 46: 25–33.

MACFARLANE, T.D., 1980: A revision of *Wurmbea* (Liliaceae) in Australia. *Brunonia* 3: 145–208.

MAY, C.E. & CAMPBELL, M.H., 1991: Polyploidy and ribosomal–DNA spacer variability in *Poa labillardieri*. *Australian Journal of Botany* 39: 367–374.

MCAULAY, A.L., 1937: Evidence for the existence of a natural hybrid between *Eucalyptus globulus* and *Eucalyptus ovata*. *Papers and Proceedings of the Royal Society of Tasmania* 1937: 45–46.

MCAULAY, A.L. & CRUICKSHANK, F.D., (1937) The male meiotic cycle in the genus *Eucalyptus*. *Papers and Proceedings of the Royal Society of Tasmania* 1937: 41–44.

MCAULAY, A.L., CRUICKSHANK, F.D. & BRETT, R.G., 1936: Chromosome number of *Eucalyptus globulus* and *Eucalyptus Johnstoni*. *Nature* 138: 550.

MCCOMB, J.A., 1970: A revision of the species *Isotoma fluviatilis*. *Contributions to the NSW National Herbarium* 4: 106–111.

MEHRA, P.N. & VIJ, S.P., 1970: *In* Löve, Á. (Ed.): IOPB chromosome number reports XXV. *Taxon* 19: 102–113.

MENADUE, Y. & CROWDEN, R.K., 1985: *In* Löve, Á. (Ed.): IOPB Chromosome number reports LXXXVIII. *Taxon* 34: 547–551.

MENADUE Y. & ORCHARD, A.E., 1985: *In* Löve, Á. (Ed.): IOPB Chromosome number reports LXXXIX. *Taxon* 34: 727–730.

MERXMÜLLER, H., FRIEDRICH, H.C. & GRAU, J., 1971: Cytotaxonomische Untersuchungen zer Gattungsstrucktur von *Crassula*. *Annalen des Naturhistorichen Museums in Wien* 75: 111–119.

MIIETA, K., 1986: Karyological study of the Slovak flora XI. *Acta Facultatis Rerum Naturalium Universitatis Comenianae, Botanica* 33: 51–55.

MIDDLETON, D.J. & WILCOCK, C.C., 1990: Chromosome counts in *Gaultheria* and related genera. *Edinburgh Journal of Botany* 47: 303–313.

MOLLOY, B.P.J. & DAWSON, M.I., 1998: Speciation in *Thelymitra* (Orchidaceae) by natural hybridism and amphidiploidy. *Royal Society of New Zealand Miscellaneous Series* 48: 103–113.

MOORE, D.M., 1960: Chromosome numbers of flowering plants from Macquarie Island. *Botaniska Notiser* 113: 185–191.

MOORE, D.M., 1964: Experimental taxonomic studies in Antarctic floras. *In* Carrick, R., Holdgate, M. & Prèvost, J. (Eds): *Biologie Antarctique*. Herman, Paris: 195–202.

MOORE, D.M., 1967: Chromosome numbers of Falkland Islands angiosperms. *British Antarctic Survey Bulletin* 14: 69–82.

MOORE, D.M., 1982: *Flora Europaea Check-List and Chromosome Index*. Cambridge University Press, Cambridge.

MORAWETZ, W. & SAMUEL, M.R.A., 1989: Karyological patterns in the Hamamelidae. *Systematics Association Special Volume* 40(2): 131–135.

MORRISON, D.A., 1989: Karyological patterns in the Hamamelidae. *Systematics Association Special Volume* 40(2): 131–135.

MORRISON, D.A., 1987: A review of the biology of *Acacia suaveolens* (Smith) Willd. (Mimosaceae). *Proceedings of the Linnaean Society of New South Wales* 109: 271–292.

MURRAY, B.G. & DE LANGE, P.J., 1999: Contributions to a chromosome atlas of the New Zealand flora – 35. Miscellaneous families. *New Zealand Journal of Botany* 37: 511–521.

MURRAY, B.G., CAMERON, E.K. & STANDRING, L.S., 1992: Chromosome numbers, karyotypes, and nuclear DNA variation in *Pratia* Gaudin (Lobeliaceae). *New Zealand Journal of Botany* 30: 181–187.

NISHIKAWA, T., 1989: Chromosome counts of flowering plants of Hokkaido (12). *Journal of Hokkaido University of Education: Section IIB* 40: 37–48.

OKUNO, S., 1939: Chromosome numbers in the genus *Carex*. *Jap. J. Genetics* 15: 332–333.

PARATHARASAY, N., 1939: Cytogenetical studies in Oryzeae and Phalarideae. *Annals of Botany N.S.* 3: 43–76.

PEACOCK, W.J., 1963: Chromosome numbers and cytoevolution in the Goodeniaceae. *Proceedings of the Linnaean Society of New South Wales* 88: 8–27.

PEAKALL, R. & JAMES, S.H., 1989: Chromosome numbers of some Australian terrestrial orchids. *Lindleyana* 4: 85–88.

RAMSAY, H.P., 1963: Chromosome numbers in the Proteaceae. *Australian Journal of Botany* 11: 1–20.

RAVEN, P.H. & KYHOS, D.W., 1965: New evidence concerning the original basic chromosome number of angiosperms. *Evolution* 19: 244–248.

RENDLE, H. & MURRAY, B.G., 1989: Chromosome relationships and breeding barriers in New Zealand species of *Ranunculus*. *New Zealand Journal of Botany* 27: 437–448.

ROBB, L. & LADIGES, P.Y., 1981: Morphological forms and polyploidy in *Triglochin procera* agg. in Victoria. *Australian Journal of Botany* 29: 639–651.

ROTHFELS, K. & HEIMBURGER, M., 1968: Chromosome size and DNA values in sundews (Droseraceae). *Chromosoma* (Berlin) 25: 96–103.

RUGGERI, C., 1960: First contribution to the karyological study of the genus *Eucalyptus* (Myrtaceae). *Centro di sperimentazione agricola e forestale. Publicazione* IV: 123–125.

RYE, B.L., 1979: Chromosome number variation in the Myrtaceae and its taxonomic implications. *Australian Journal of Botany* 27: 547–573.

SANDS, V.E., 1960: *Aspects of the Classification and Generic Relationships of the New Zealand Epacridaceae*. Unpub. MSc thesis, University of Auckland, Auckland, New Zealand: 98 pp.

SHORT, P.S., 1979: *Apium* L. sect. *Apium* (Umbelliferae) in Australasia. *Journal of the Adelaide Botanical Gardens* 1: 205–235.

SINGH, R.J., KOLLIPARA, K.P. & HYMOWITZ, T., 1988: Further data on the genomic relationships among wild perennial species ($2n = 40$) of the genus *Glycine* Willd. *Genome* 30: 166–176.

SMITH, P.J., 1992: A revision of the genus *Wahlenbergia* (Campanulaceae) in Australia *Telopea* 5: 91–175.

SILVESTRE, S., 1986: Números cromosómicos para la flora Española, 435–455. *Lagascalia* 14: 273–281.

SINGHAL, V.K. & GILL, B.S., 1984: SOCGI plant chromosome number reports – II. *Journal of Cytology and Genetics* 19: 115–117.

SINGHAL, V.K., GILL, B.S. & SIDHU, M.S., 1990: Cytological explorations of Indian woody legumes. *Proceedings of the Indian Academy of Sciences. Plant Science* 100: 319–331.

SMITH–WHITE, S., 1948: A survey of chromosome numbers in the Epacridaceae. *Proceedings of the Linnaean Society of New South Wales* 73: 37–56.

SMITH–WHITE, S., 1954: Chromosome numbers in the Boronieae (Rutaceae) and their bearing on the evolutionary development of the tribe in the Australian flora. *Australian Journal of Botany* 2: 287–303.

SMITH–WHITE, S., 1955: Chromosome numbers and pollen types in the Epacridaceae. *Australian Journal of Botany* 3: 48–67.

STACE, H.M., 1981: Biosystematics of the *Brachycome aculeata* (Labill.) Less. *sensu* G.L. Davies species complex (Compositae: Asterae). *Australian Journal of Botany* 29: 425–440.

STACE, H.M. &. ARMSTRONG, J.A., 1992: New chromosome numbers for Rutaceae. *Australian Systematic Botany* 5: 501–505.

STACE, H.M. & JAMES, S.H., 1996: Another perspective on cytoevolution in Lobelioideae (Campanulaceae). *American Journal of Botany* 83: 1356–1364.

STOEVA, M.P., 1985: Chromosome numbers of Bulgarian angiosperms. *Fitologija (Sofia)* 30: 78–79

STOEVA, M., 1994: Mediterranean chromosome number reports 4 (285–293). *Flora Mediterranea* 4: 258–262.

STRAUB, J., 1938: *In* Darlington, C.D. & Wylie, A.P., 1955: *Chromosome Atlas of Flowering Plants*. 2nd edn. Allen & Unwin, London.

SUN, B.Y., STUESSY, T.F. & CRAWFORD, D.J., 1990: Chromosome

counts from the flora of the Juan Fernandez Islands, Chile. III. *Pacific Science* 44: 258–264.

Sundar Rao, Y., 1959: *Cytological Studies in the Tasmanian Conifers, the Indian Scilia and Dipcadi.* Unpub. Ph.D. thesis, University of Tasmania, Hobart.

Talavera, S. & García Murillo, P., 1992: Números cromosomáticos de plantas occidentales, 661–667. *Anales del Jardín Botánico de Madrid* 50: 83.

Tanaka, N., 1939: Chromosome studies in the Cyperaceae, IV. Chromosome number in *Carex* species. *Cytologia* 10: 51–58.

Tijo 1948: *In* Darlington, C.D. & Wylie, A.P., 1955: *Chromosome Atlas of Flowering Plants.* 2nd edn. Allen & Unwin, London.

Turner, B.L., 1966: Chromosome numbers in *Stackhousia* (Stackhousiaceae). *Australian Journal of Botany* 14: 165–166.

Turner, B.L., 1970: Chromosome numbers in the Compositae. XII. *American Journal of Botany* 57: 382–389.

Uchiyama, H., 1989: Karyomorphological studies on some taxa of the Helobiae. *J. Sci. Hiroshima University, Series B, Division 2 (Botany)* 22: 271–352.

Urbanska–Worytkiewicz, K., 1980: Cytological variation within the family of Lemnaceae. *Veröffentchungen des Geobotanischen Institutes der ETH, Stiftung Rübel, Zurich* 70: 30–101.

Van Der Walt, J.J.A. & Vorster, P.J., 1989: Pelargoniums of southern Africa. *Annals of Kirstenbosch Botanic Gardens* 16.

Venkata Rao, C., 1957: *Cytotaxonomic Studies in the Proteaceae.* Unpub. Ph.D. thesis, University of Tasmania, Hobart.

Vij, S.P. & Shekhar, N., 1983: *In* Löve, Á. (Ed.): IOPB chromosome number reports LXXXI. *Taxon* 32: 663–669.

Vij, S.P., Shekhar, N. & Kuthiala, R., 1981: *In* Löve, Á. (Ed.): IOPB chromosome number reports LXXI. *Taxon* 30: 512.

Warburg, E.F., 1938: Taxonomy and relationship in the Gerniales in light of their cytology. Part 1. *New Phytologist* 37: 130–159.

Watanabe, K. & Short, P. S., 1992: Chromosome number determination in *Brachyscome* Cass. (Asteraceae: Asteraeae) with comments on species delimitation, relationships and cytogeography. *Muelleria* 7: 457–471.

Watanabe, K., Short, P.S., Denda, T., Suzuki, Y., Ito, M., Yahara, T. & Kosuge, K., 1996: Chromosome number determinations in the Australian Astereae (Asteraceae). *Muelleria* 9: 197–228.

Watson, E. M., 1988: C–Banding patterns in the Australian *Bulbine* (Liliaceae): the annual group, *B. semibarbata* s. lato. *Plant Systematics and Evolution* 159: 1–7.

Webb, C.J. & Beuzenberg, E.J., 1987: Contributions to a chromosome atlas of the New Zealand flora – corrections and additions to number 21 Umbelliferae (*Hydrocotyle*). *New Zealand Journal of Botany* 25: 371–372.

Weber, J.Z., 1981: A taxonomic revision of *Cassytha* (Lauraceae) in Australia. *Journal of the Adelaide Botanical Gardens* 3: 187–262.

Wentworth, J.E., Bailey, J.P. & Gornall, R.J., 1991: Contributions to a cytological catalogue of the British and Irish flora, 1. *Watsonia* 18: 415–417.

West, J.G., 1984: A revision of *Dodonaea* Miller (Sapindaceae) in Australia. *Brunonia* 7: 1–194.

West, K.R. & Raven, P.H., 1977: Novelties in Australian *Epilobium* (Onagraceae). *New Zealand Journal of Botany* 15: 503–509.

Westphalen, G. & Conran, J.G., 1994: Chromosome numbers in the *Arthropodium–Dichopogon* complex (Asparagales: Anthericaceae). *Taxon* 43: 377–381.

Wiltshire, R.J.E. & Stace, H.M., 1997: The cytotaxonomy of four Tasmanian genera of Proteaceae. *Telopea* 7: 181–185.

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SHEDDING SOME LIGHT ON *THISMIA RODWAYI* F. MUELL. (FAIRY LANTERNS) IN TASMANIA: DISTRIBUTION, HABITAT AND CONSERVATION STATUS

by N. Roberts, M. Wapstra, F. Duncan, A. Woolley, J. Morley and N. Fitzgerald

(with one plate, five tables, four text-figures and one appendix)

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Thismia rodwayi is a seldom-seen, subterranean plant that occurs in Tasmania, the eastern states of the Australian mainland and New Zealand. Surveys for the species were prompted by a new record from Archers Sugarloaf near Meander in Tasmania's central north. Several new populations of the species were subsequently discovered in wet eucalypt forests dominated by *Eucalyptus obliqua, E. regnans, E. delegatensis* or *E. viminalis*, with an understorey dominated by *Pomaderris apetala, Bedfordia salicina* and/or *Olearia argophylla*. The species is now known from the Meander, Glen Huon, Little Denison River, Mount Field, Mount Wellington and Ben Lomond areas. Analysis of current information suggests that the listing of *T. rodwayi* under Schedule 5 (Rare) of the Tasmanian *Threatened Species Protection Act 1995* is appropriate.

INTRODUCTION

Thismia rodwayi F. Muell. is an herbaceous flowering plant with an unusual subterranean habit (pl. 1, fig. 1). It is a member of the largely saprophytic monocot family Burmanniaceae, which includes over 120 species worldwide, most of which occur in the tropics and subtropics.

Since the holotype of *T. rodwayi* was collected in Tasmania in 1890, the species has been recorded in Victoria, New South Wales, Queensland and New Zealand (Willis 1970, Moore & Edgar 1976, Conn 1994). It is currently listed under Schedule 5 (Rare) of the Tasmanian *Threatened Species Protection Act 1995*, and it has been similarly listed in other states under equivalent legislation. Two other species of *Thismia* occur on the Australian mainland (*T. clavarioides* Thiele & Jordan, 2002; *T. yorkensis* Cribb, 1995).

The discovery of *T. rodwayi* in the Archers Sugarloaf area near Meander in November 2002 provided an opportunity to assess its habitat requirements, wider distribution and conservation status. This paper reports on the ecology and distribution of the species, particularly in the Meander area, and provides an overview of information on the species.

TAXONOMY, MORPHOLOGY AND BIOLOGY

Thismia rodwayi has been known by various scientific epithets (most honouring the collectors of this charismatic plant) including *Bagnisia rodwayi, B. hillii, Rodwaya thismiacea, Sarcosiphon hillii* and *S. rodwayi* (Jonker 1938). The common name ascribed to *Thismia rodwayi* is 'fairy lanterns'. This name aptly describes the appearance of the small, orange and red, fleshy flowers that barely penetrate the soil surface and are typically covered by leaf-litter. These brightly-coloured flowers are 10–18 mm in length and have an obovate longitudinally striped floral tube (the 'lantern'), surmounted by six perianth lobes — the inner three arching inward and cohering at the top, and outer lobes spreading (pl. 1, fig. 1). The vegetative part of the plant is entirely subterranean and is colourless. The roots are about 1–1.5 mm thick and 4–15 cm long. They give rise to erect flower stems (0.5–3 cm), which bear about six colourless leaf-like bracts, which increase in size toward the terminal flower (Conn 1994). The plant lacks chlorophyll and is therefore incapable of photosynthesis. It is commonly considered a saprophyte, although this term

PLATE 1

Thismia rodwayi in situ, *showing growth habit (note: surface leaf litter has been removed).*

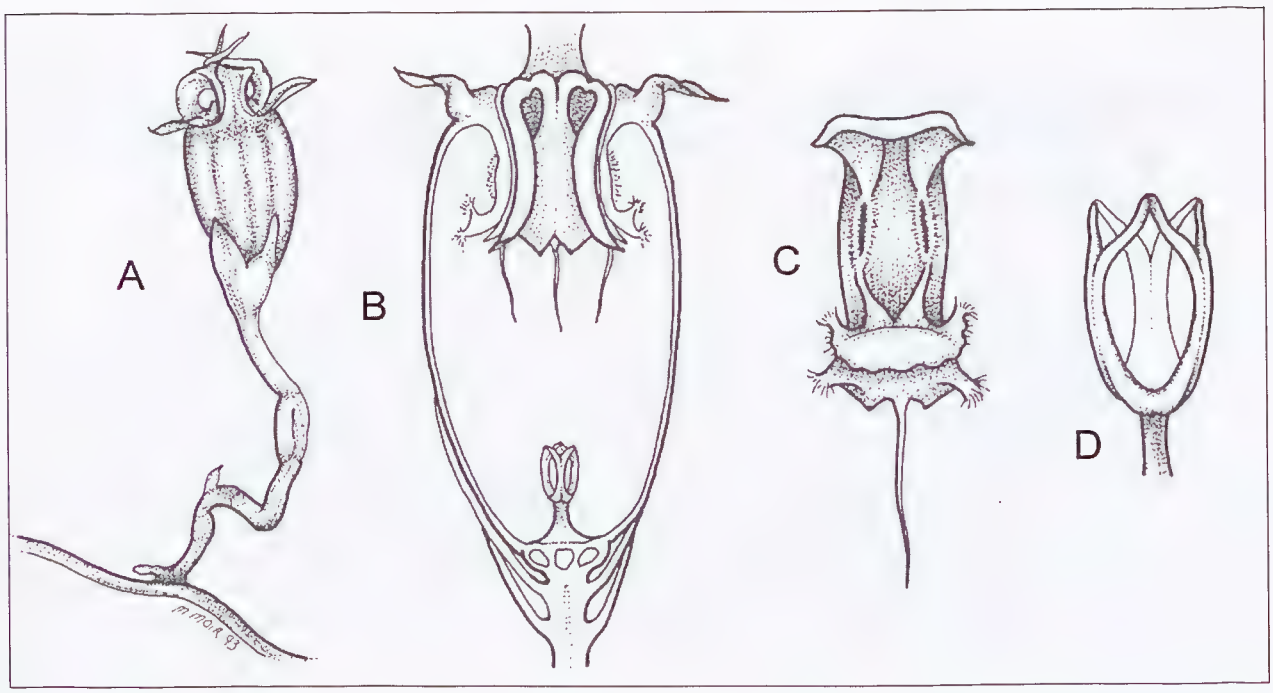

FIG. 1 — Thismia rodwayi. *(A) habit x2; (B) flower, longitudinal section, x4; (C) stamen x6; (D) style and stigmas x10. Original line drawing by M. Moir, used with permission from Conn (1994). It should be noted that this line drawing is based on the drawing of Coleman (1936) and there may be some inaccuracy around the style detail in the longitudinal section.*

is slightly misleading as it derives its energy from a fungus — the fungus being the true saprophyte.

As in most saprophytic plants, the fungal hyphae exist inside some of the root cells of *Thismia* plants, and convert rotting material into sugars using specialised enzymes. The plant can obtain carbohydrates by digesting the fungus (known as an endophyte). McLennan (1958) studied the relationship of *T. rodwayi* with its endophyte. Most of the cells in the root cortex were occupied by fungal hyphae, and a cobwebby coating of hyphae was also mixed with humus around the root. Sectioning of the root at intervals from the growing tip revealed that the fungus inside the cortex cells accumulates fat globules in hyphal bladders, which discharge their contents into their host cells, presumably due to a digestive action of the host. The fat globules appear to be converted into a polysaccharide, probably glycogen (McLennan 1958).

A similar study of *T. rodwayi* in New Zealand (Campbell 1968) also found this type of hyphal infection, with rhizomorphs (root-like aggregations of hyphae) also able to infect the roots of *Thismia*. The fungus that occupies the roots of *T. rodwayi* (either as hyphae or rhizomorphs) in New Zealand is largely an inhabitant of dead parenchyma cells among layers of corky bark of the trees typically growing near *T. rodwayi* populations (Campbell 1968). Such an association with the surrounding vegetation has not been established for the endophyte of *T. rodwayi* in Australia.

ECOLOGY AND DISTRIBUTION

Much of the current information on the habitat and distribution of *T. rodwayi* is anecdotal (e.g., Coleman 1936, 1941), and the reproductive biology and life-cycle are poorly understood. Pollination and dispersal agents, flowering interval and germination conditions are largely speculative. One source states that flowering occurs from spring to autumn, and fruits (fleshy cup-shaped capsules) are borne on the plant during summer and autumn (CCRPL 2002). This source also notes that the species occurs in several vegetation types on different geologies, but cool, moist, humic soils are favoured. Conn (1994: 739) states that the preferred habitat of this species is "damp humus and leaf litter in deeply shaded tall forests and fern gullies". Curtis & Morris (1994: 424) note that the species is "seldom seen but widespread in damp humus and litter in wet forests, recorded in association with roots of *Bedfordia salicina*, *Olearia argophylla* and *Coprosma quadrifida*" but make no mention of the season or duration of flowering. Rodway (1903: 208) indicated that the species was known only from a "gully on [the] eastern slope of Mount Wellington", his original collection site, where he recorded the species was associated with the roots of *Olearia argophylla*. Rodway (1903) stated that the species flowers from December to January. It is not known whether Rodway's comment was based on his own ongoing observations of the original population; there have been no subsequent Tasmanian records of *T. rodwayi* flowering in January.

HISTORICAL RECORDS OF *THISMIA RODWAYI* IN TASMANIA

Until the present study, there were only four records of *T. rodwayi* held by the Tasmanian Herbarium (table 1, fig. 2): from the lower slopes of Mount Wellington (1890), Mount Field (1923), Little Denison River (1968) and Lenah Valley (2002). The species was described by Baron Ferdinand von Mueller in 1890 (von Mueller 1890b) from specimens collected by Leonard Rodway in Tasmania from "near the Derwent". Baron von Mueller was astonished that a *Thismia* species was found in such temperate latitudes, stating: "...not as might have been looked for in North-Eastern Australia,

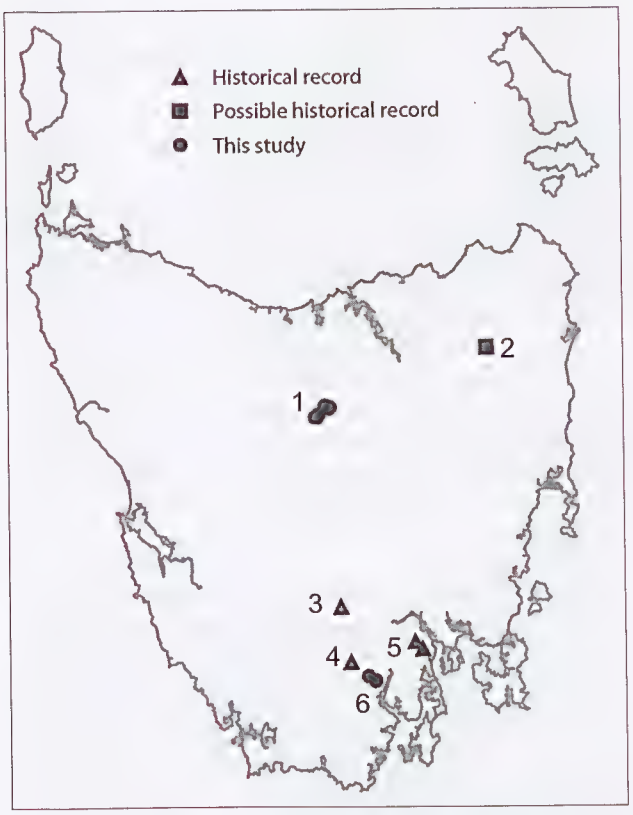

FIG. 2 — Known distribution of Thismia rodwayi *in Tasmania. Numbers refer to areas of the State mentioned in the text: 1. Meander area (including Archers Sugarloaf); 2. Ben Lomond area; 3. Mt Field area; 4. Little Denison River area; 5. Mt Wellington area; 6. Glen Huon area (note that the possible site from the 1980s is not shown for clarity – see text for details).*

but in such an extreme extratropic isolation, is one of the most remarkable additions to our recent knowledge in this direction" (von Mueller 1890a: 234). A letter from Sir Joseph Hooker to Baron von Mueller, found in the folder containing specimens of *T. rodwayi* from Tasmania at the Melbourne Herbarium contains the following passage (source: Coleman 1936: 164): "I have this morning received your account of the Tasmanian *Thismia* — it is really like a dream: since any preconceived idea of that genus turning up there would have been scouted by every reasoning naturalist who heard it. Had it been fossilized only it would have revolutionized [our idea of? (D.C.)] the former climate of the Southern Hemisphere".

Curtis & Morris (1994) indicate that *T. rodwayi* occurs in the Ben Lomond, South West, Mount Field and Mount Wellington floristic regions (Orchard 1988) of Tasmania. The illustration of the species in Curtis & Morris (1994) is based on a specimen from the Ben Lomond region but this specimen was not curated and therefore does not appear on the herbarium records (A. Buchanan, pers. comm.). The species was also reliably observed from the Neika area on the slopes of Mount Wellington in the 1980s (R. Jones, pers. comm.), and plants delivered to the Tasmanian Herbarium but none of these specimens is in the current collection.

METHODS

Collation of Known Records

Historical records for *T. rodwayi* were collated from a variety of sources including database searches (e.g., DPIWE's GTSpot database) and herbaria including the Tasmanian Herbarium (HO) and the National Herbarium of Victoria (MEL). Personal communication with numerous botanists, naturalists and other field workers who may have seen the species (such as those who regularly survey for litter invertebrates) was also undertaken.

TABLE 1
Historical records of *Thismia rodwayi* held by the Tasmanian Herbarium (HO)

Locality[1]	Date	Collector	Latitude, longitude	HO number
Cascades, Hobart[2]	Dec 1890[4]	L. Rodway	42°54',147°17'	25468
Mt Field track [Lake Dobson Road]	Nov 1923	L. Rodway	42°41',146°42'	23812
Link Road between Russell River Road and Little Denison River[3]	20/10/1968	B. Reid & W.M. Curtis	42°58',146°46'	115634
Little Denison River, via Judbury[3]	1968	B. Reid	42°58',146°46'	51377
~70 m uphill from the Lenah Valley fire track	01/11/2001	S. McMullen-Fisher	42°52',147°15'	519153

[1] Locality descriptions are as they appear on the herbarium sheet.
[2] Specimens from the same site are also held at National Herbarium of Victoria MEL (type specimen) with duplicates at Royal Botanic Gardens, Kew, and Botanischer Garten und Botanisches Museum, Berlin-Dahlem.
[3] Specimens from the same site but held on different herbarium sheets.
[4] The specimen at HO has a date of Dec 1890, but specimens in MEL are dated 16/11/1890.

Field Surveys

The catalyst for this study was the incidental discovery of *T. rodwayi* on Archers Sugarloaf near Meander in Tasmania's central north, during an Understorey Network field day (15 October 2002) in an area of State forest proposed for logging. The two specimens found on this occasion were detached flowers lying on the soil surface, apparently after being unearthed by animals. The subsequent survey work focused initially on the general vicinity of this find, both within the proposed logging coupe and other forest sites in the Meander area. Less extensive surveys were carried out later in other regions of the state. Sites and survey methods are described below.

Archers Sugarloaf coupe

The proposed coupe on Archers Sugarloaf (known as HU302D) is on a gently-sloping bench with a northerly aspect, on Jurassic dolerite and dolerite talus. Vegetation within the coupe graded from wet to dry sclerophyll forest and had a multi-aged structure, including some old-growth trees. *Eucalyptus obliqua* L'Hérit. is the dominant tree, with *E. amygdalina* Labill., *E. viminalis* Labill. and *E. delegatensis* subsp. *tasmaniensis* Boland also present. Stumps with shoe marks throughout the area indicated that selective logging had occurred more than 50 years ago, and it is likely that the area was also logged for sleepers in the 1960s.

Two sampling methods were used in coupe HU302D on 9–10 December 2002 to both systematically search a range of habitats and maximise the probability of finding populations of *T. rodwayi*.

Stratified random sampling: In all, 13 sites were sampled across a range of habitats within the coupe. They were spaced 100–400 m apart using a quadrat-based sampling method. Five 1 m^2 quadrats were established at each site, the first quadrat being positioned by random throw, and the subsequent quadrats being located at cardinal points about 5 m distant from the first quadrat. The leaf litter was removed from within each quadrat, and the soil excavated to a depth of 1–5 cm. Details of the vegetation were recorded at each site, including approximate height and cover of each stratum. For the purposes of the vegetation description, each site was defined as an area of approximately 10 m radius.

Focused sampling: Seven of the 13 sites sampled using the stratified random approach supported wetter forest types that were apparently favourable *T. rodwayi* habitat (based on the observations from the surveys in HU302D and sites of historical records). These sites were more intensively surveyed using the same scratching and excavation techniques but without the use of quadrats. The additional area searched was estimated for each intensively sampled site. Within each of the intensively surveyed sites, a proportion of ground (up to 50%) was clearly not suitable habitat, because of the presence of localised obstacles such as large rocks, logs and the standing trunks of trees and tall shrubs.

A preliminary search conducted within the coupe on 15 November 2002 used similar methods to those adopted for the intensively sampled sites. The data from these initial sites are therefore included as part of this study. The two detached *T. rodwayi* flowers found incidentally on 15 October 2002, which instigated this study, are not included in the results presented here because we are not certain that they were actually excavated at these sites. One site, noted for its abundance of *T. rodwayi* flowers during the December survey work, was re-inspected in mid-February 2003.

Wider Meander area

Thirteen sites on State forest within about 10 km of the Archers Sugarloaf coupe (HU302D) were sampled on 10–11 December 2002 based on apparent suitability of *T. rodwayi* habitat and physical accessibility. The judgement of habitat suitability was based on observations made during the more systematic sampling of the Archers Sugarloaf (see above). Habitat variables recorded for each site were the same as those used in the Archers Sugarloaf survey. Geology was also recorded in each case. It should be noted that much of the forest in the Meander area has been subject to extensive forestry activities since the 1950s. However, we did not attempt to stratify the sampling according to logging regime or the forest age.

Additional areas

It was not possible to conduct a statewide survey for *T. rodwayi* as part of this study. However, we considered it prudent to examine sites of historical records, where locatable, to determine if the species could still be found at these sites. Forest in the approximate location of the site of the 1968 record at the Little Denison River (based on the description of the site on the herbarium specimen sheet) was searched on 18 December 2002. The site of the recent 2002 record from Lenah Valley, near Hobart on the lower slopes of Mount Wellington (Cascades), was searched on 10 January 2003. However, the site of the reliable sighting near Neika on the slopes of Mount Wellington was not searched as information on this site was obtained after the flowering period of the species. The sites of the records of Rodway from Mount Wellington and the Mount Field area were not re-surveyed due to the lack of information on their exact location.

Based on an unconfirmed sighting of the species in the late 1980s (K. Bonham, pers. comm.), an area at the end of New Road, near Franklin, was searched on 18 December 2002, as were several other sites with similar habitat within the vicinity.

Specimen collection

Specimens were collected from numerous locations under permits issued by the Department of Primary Industries, Water and Environment (DPIWE). Collected specimens were lodged at the Tasmanian Herbarium (HO).

Conservation assessment

The Conservation Status Assessment Program developed by the Threatened Species Unit (DPIWE 2002) was used to assess the conservation status of *T. rodwayi* in Tasmania. Population size was entered as 'unknown' due to the difficulty in estimating the size of all of the known populations for the species. The distribution of the species was based on both recent and historical records, but not extended to potential habitat where no records exist.

RESULTS

Distribution of *Thismia rodwayi* in Tasmania

The known distribution of *T. rodwayi* in Tasmania is shown in figure 2, and all sites are listed in appendix 1. The species has a disjunct distribution (Meander, Ben Lomond, Mount

Wellington, Mount Field, Glen Huon and Little Denison River area) and is known from over 20 sites.

Population Details and Habitat Characteristics

In the following discussion, the term 'flower' is used to describe specimens of *T. rodwayi* recorded in various stages of flowering. In addition, a single 'flower' is equated to an individual plant (because our excavations did not extend to clearing of soil from the delicate root system from which one or more flowers may have arisen).

A total of 110 flowers of *T. rodwayi* were found in the Meander area and a further 12 in the south of the state in the course of this survey. For each general survey area, a summary of observations regarding habitat characteristics and population sizes are given below.

Archers Sugarloaf coupe

Thismia rodwayi was recorded once only using the stratified random sampling method. However, the focused sampling at sites that represented prospective habitat resulted in *T. rodwayi* being found at seven sites. The number of individual flowers found within each 'population' ranged from one to 24. A total of 56 flowers was recorded from approximately 150 m^2 of ground examined over the 16 sites. Location, general environmental data and number of flowers recorded for all sites searched within the coupe are given in table 2, and shown in figure 3. Also marked on figure 3 is the approximate location of five sites (sites a, b, c, d and e) informally searched for *Thismia* during our preliminary search on 15 November 2002.

All records from the coupe area were from patches of wetter vegetation, not in the dry/damp sclerophyll forest that occupied most of the coupe area. *Eucalyptus obliqua* was the dominant canopy species throughout the coupe, and *Pteridium esculentum* (Forst.f.) Cockayne, *Coprosma quadrifida* (Labill.) Robinson and *Pultenaea juniperina* Labill. were common in the understorey. Understorey species that were especially prominent where *T. rodwayi* was found included *Bedfordia salicina* (Labill.) DC., *Pomaderris apetala* Labill. and *Blechnum nudum* (Labill.) Mett. ex. Luerss.

No *T. rodwayi* flowers were found in mid-February during a re-inspection of one site within the Archers Sugarloaf survey area where flowers had been abundant in December (site 8, table 2).

A rough estimate of the number of *T. rodwayi* individuals within the area of the proposed coupe (approximately 100

TABLE 2
Details of sites searched for *Thismia rodwayi* on Archers Sugarloaf

Site[1]	Easting	Northing	Altitude (m)	Slope (°)	Aspect	Landform	Rock cover (%)	Drainage	Scratched (x 1m^2)	Number of *Thismia*
Positive sites										
4	468008	5386663	445	2	NE	Mid-slope/shelf	10-20	mod-good	11	3
8[2]	468500	5387020	405	<2	NE	Mid-slope/shelf	<2	good	20	24 (plus 15 [3])
10	467597	5387160	435	2	N	Shelf	<5	fair	15	2
11	467759	5387242	430	2	N	Shelf	<5	good	15	1
a	467940	5387408	415	<5	N	Mid-slope/shelf	<5	good	15	3
b	467647	5387340	425	0	0	Shelf	0	fair/good	15	5
c	467621	5387245	436	<2	N	Shelf	<5	good	15	3
Negative Sites										
1	467628	5386771	470	<5	NE	Mid-slope	5	good	5	0
2	467713	5386834	455	<5	NE	Mid-slope	<5	good	5	0
3	467814	5386795	455	<5	NE	Mid-slope	5	good	5	0
5	468166	5386516	440	5	NE	Mid-slope	5	good	5	0
6	468319	5386449	425	5	E	Drainage depression	5	fair	5	0
7	468609	5386594	405	<5	E	Mid-slope	30-40	good	5	0
9	467507	5387108	405	0		Shelf	5	good	5	0
12	467833	5387111	437	3	NNE	Shelf	30	good	5	0
13	468209	5386901	425	1	NE	Shelf	0	fair	5	0

[1] Sites 1–13 were surveyed on 9–10 December 2002. Sites a, b and c were surveyed during a preliminary search on 15 November 2002.

[2] One flower was found using the quadrat sampling method at this site.

[3] These additional 15 flowers were about 20 m north of the formally sampled and described site, but were too close to be considered an additional site. *Pomaderris apetala* rather than *Olearia argophylla* was locally dominant; however, the site was otherwise very similar.

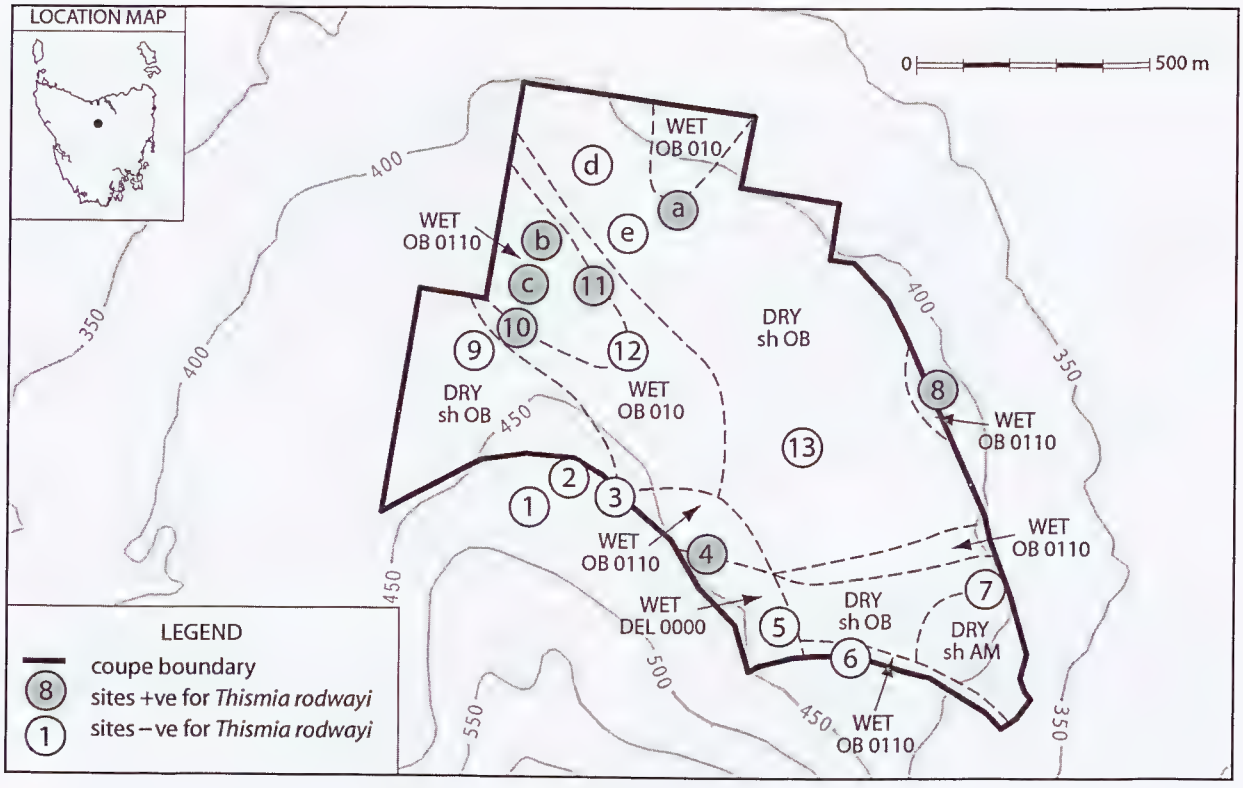

FIG. 3 — Coupe HU302D with sites searched for Thismia rodwayi *and forest communities shown (forest community nomenclature follows that of North* et al. *(1998)). The forest communities as mapped may contain localised areas of other communities. Numbers and letters refer to sample sites (see table 2 and text).*

ha) can be made from the density of plants within searched areas, and the extent of suitable habitat. The apparently suitable forest types occupied about 30 ha. A conservative assessment suggests that obstructions such as logs, rocks and other vegetation prevent about half this area being occupied by *T. rodwayi*, thus the potential habitat is reduced to 15 ha. The total area intensively surveyed in these wetter forests was 151 m^2 (over 16 sites), uncovering 56 flowers. If the species were to occupy the estimated 15 ha of potential habitat at the same density as in surveyed areas, the total population would be about 70 000.

Wider Meander area

Thismia rodwayi was found at seven of the 13 sites searched within the wider Meander area (table 3 and fig. 4). All sites surveyed were in wet sclerophyll forest and were mainly on dolerite or dolerite talus, the most extensive substrate in the Meander area. The total number of *T. rodwayi* flowers found in this area was 54. The total area searched was approximately 114 m^2 (average of 8.8 m^2; range of 7–27 m^2).

Additional areas

Thismia rodwayi was not found in the Little Denison River area. The current habitat in this site appeared dry (very low moisture in leaf litter) compared to sites supporting the species in the Archers Sugarloaf/Meander area. The geology was Permian mudstone.

The species was not found at the Lenah Valley site (where it had been found in late spring 2002) when it was searched in January 2003. The leaf litter and soil were very dry following atypically dry conditions in southeastern Tasmania for the preceding three months. The vegetation was very similar to other *T. rodwayi* sites, with a dense tall shrub layer of *P. apetala* and *Olearia argophylla* (Labill.) Benth. below a eucalypt canopy dominated by *Eucalyptus regnans* F.Muell. and *E. obliqua*. This site was on Permian mudstone.

Seven flowers of *T. rodwayi* were found at the end of New Road, near Franklin (Glen Huon area), at about the same location as the anecdotal sighting by K. Bonham in the late 1980s (table 4). Five of these were in a single clump, and two were located about 100 m distant within about 10 m of each other. These plants were situated on a west-facing slope on Jurassic dolerite. The dominant canopy tree was *E. delegatensis*. *Atherosperma moschatum* Labill., *P. apetala* and *B. salicina* formed a thick tall shrub layer. *Blechnum wattsii* Tind. was common but only locally dense.

Five flowers of *T. rodwayi*, in a single clump, were recorded at Blue Gum Hill, about 4.5 km from the above-mentioned site, and also on Jurassic dolerite (table 4). This site was dominated by *E. regnans* regrowth (approximately 30–40 years old) with a 5–15 m tall understorey of *Pomaderris apetala*, *Olearia argophylla* and *Acacia melanoxylon* and a moderately dense fern layer (mostly *Polystichum proliferum*).

General Observations

Thismia rodwayi was found in various stages of flowering, from small buds to senescent flowers and early stages of fruit formation. Flowers in different stages of development were often found at the same site. Flowers occurred in a humus layer where fungal hyphae were prominent at the interface between soil and leaf litter and occasionally just below the soil surface. Leaf litter covered them in all cases and was typically

TABLE 3
Sites searched for *Thismia rodwayi* in the Meander area, excluding Archers Sugarloaf

Location or coupe name	Easting	Northing	Altitude (m)	Slope (°)	Aspect	Landform	Geology	Rock cover (%)	Drainage	Scratched (m^2)	Number of *Thismia*
Positive sites											
Warners Sugarloaf	470277	5386284	450	<5	NW	Mid-slope	Dolerite	<5	good	5	5
East of Meander River	462859	5380724	610	10	N	Drainage depression	Dolerite talus	5	fair-good	8	7
Jackeys Creek FR[1]	470474	5386494	440	20-25	SE	Slope near river	Dolerite	<3	good	10	13
Warners Sugarloaf	469875	5385927	435	1	W	Mid-slope	Dolerite	<5	good	7	3
Meander River SSR	463447	5381741	510	20	N	Gully	Dolerite talus	5-10	fair-good	25-30	5
Meander River SSR	461997	5380691	590	3	N	Drainage depression	Dolerite talus	5	fair-good	20-25	18
Meander River SSR	463980	5382231	465	1-3	N	Riparian flats	Dolerite talus	<1	fair	10-12	3
Negative sites											
Warners Sugarloaf	470222	5386288	450	5	NW	Mid-slope	Dolerite	<5	good	25	0
Smoko Rd	462752	5383020	570	25-30	S	Mid-slope	Permian mudstone	<3	good	20	0
Smoko Rd	462084	5383300	600	25-30	S	Mid-slope	Permian mudstone	<5	good	15	0
Smoko Creek SSR	463828	5382583	470	0		Riparian flats	Permian mudstone	<2	poor-fair	17	0
Meander River SSR	465160	5382723	435	0	NE	Riparian flats	Dolerite talus	<5	fair	10	0
Meander FR	461983	5380679	600	15	E	Mid-slope	Permian mudstone	7-10	good	7	0

[1] Abbreviations used: SSR = streamside reserve; FR = Forest Reserve. All sites are in State forest.

2–4 cm thick. The composition of the leaf litter was variable but broad-leaved understorey species such as *B. salicina* and *P. apetala* were the main components.

Flowers of *T. rodwayi* were borne on a short vertical white stalk, less than 5 cm long, attached at right angles to a vermiform white root, about 5–15 cm long. Generally there was only one flower per plant, although one specimen was found with two flowers, each on a separate stalk attached to the same root.

Flowers (putatively representing individuals) were commonly found in groups of 2–5 (although sometimes up to 12) across an area of less than 1 m^2. Several such clumps were observed at the sites where the species was most abundant. These clumps were sometimes close enough to appear as one large clump (i.e., less than about 2 m apart) or were seemingly 'connected' by one or two flowers spaced between them.

It is difficult to determine whether all individuals within the surveyed area on Archers Sugarloaf are part of a single population, or whether they belong to a number of small isolated populations, separated by drier forest. This is due to the paucity of knowledge of the pollination and distribution mechanisms of this species. While information on this aspect of the species' biology remains lacking, estimates of functional population size and extent can only be tentative (see discussion below).

DISCUSSION

Distribution and Ecology of *Thismia rodwayi*

In 1890, Baron von Mueller made the following comments about *T. rodwayi*: "... that so remarkable, and to some extent also showy plant should have evaded hitherto observation, although since almost nearly 100 years the region about the estuary of the Derwent has been searched for plants, finds perhaps its explanation in the fact, that in all likelihood the flower only is peeping above the soil between decaying foliage, and thus might be easily taken for a young Aseroe or some other fungus ... furthermore, each flower must be very ephemerous and perishable ... now it will likely be found in other places of the island, perhaps, also, in New Zealand and in Continental Australia" (von Mueller 1890a: 233).

The baron was right in all aspects of his somewhat flowery statement: the species has indeed been found elsewhere in Tasmania, New Zealand and mainland Australia. In Tasmania, *T. rodwayi* is now known from several disjunct sites including recent records in the Meander area, an uncurated but reliable record from the northeast of the State, historical records from the Mount Field area, and recent and historical records from the Mount Wellington, Glen Huon and Little Denison River areas (fig. 2; Appendix 1).

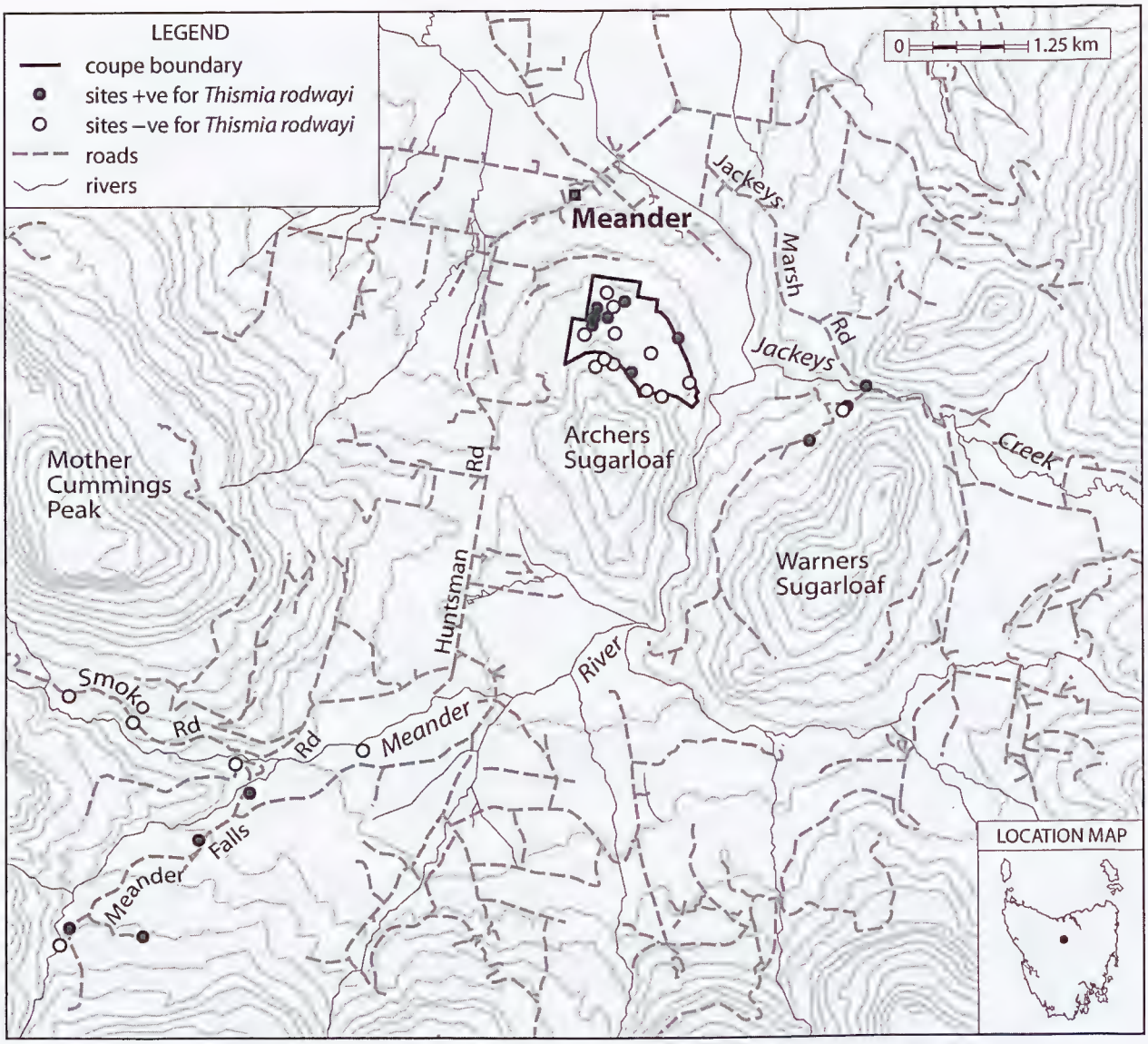

FIG. 4 — The Meander area, showing sites searched for Thismia rodwayi.

TABLE 4
Additional sites from the south of the state where *Thismia rodwayi* was recorded

Location	Easting	Northing	Altitude (m)	Slope (°)	Aspect	Landform	Geology	Rock cover (%)	Drainage	Scratched (m^2)	Number of *Thismia*
New Rd, Franklin	495197	5230445	435	5–10	W	midslope	Dolerite	5–10	good	10	5
New Rd, Franklin	495195	5230252	440	10	W	midslope	Dolerite	20	good	10	2
Blue Gum Hill, near Glen Huon	491200	5232900	470	10	SW	midslope	Dolerite	10–20	good	15	5

The present study extends the distribution of the species to include the northern part of the Midlands floristic region (as defined by Orchard 1988).

Von Mueller originally mused "...whether it lives exclusively on the roots of the Musk-Aster, or whether it is nourished also by the roots of any other plants ..." but continued in the same manuscript that "... he [Mr Rodway] noticed the plant to grow also on the roots of *Bedfordia* ..." (von Mueller 1890a: 233, 235). Tasmanian site records, and information from the present study, suggest that *T. rodwayi* is strongly associated with wet sclerophyll forest (*E. obliqua, E. regnans, E. delegatensis* or *E. viminalis*) with an understorey dominated by any or all of *P. apetala, O. argophylla, B. salicina* or *Acacia melanoxylon* (often most of these species are present). In Victoria, the species appears to occur in wetter forest types associated with *O. argophylla* and *Bedfordia arborescens* Hochr. (N. Walsh, pers. comm.). Although *E. obliqua* was commonly the dominant eucalypt around Meander, the occurrence of *T. rodwayi* at some sites with *E. delegatensis, E. regnans* and *E. viminalis* occurring as dominants or co-dominants suggests eucalypt species may not be a relevant factor in defining suitable habitat. The presence of *Thismia* in the Archers Sugarloaf coupe was strongly associated with the presence of *Blechnum nudum.* However, this was not the case in other areas, especially the wetter forest types sampled near the Meander River and at New Road near Franklin, which had a relatively sparse ground fern layer. The Archers Sugarloaf coupe is at the drier end of the habitat spectrum of *T. rodwayi,* and it seems likely that in this forest type *B. nudum* is indicative of wetter sites such as soaks and springs and therefore more suitable *T. rodwayi* habitat. Ground ferns may also help to create a suitable microhabitat when a dense shrub layer is lacking, although *T. rodwayi* was rarely recorded within very dense patches of *B. nudum.*

We had a surprisingly high success rate in recording *T. rodwayi,* considering the cryptic nature of the species. Rodway, when supplying additional specimens to von Mueller in 1890, wrote: "Herewith the result of a whole days search. One flower, one bud and pieces of rhizome ...". It is premature, however, to assume that the species has an extensive distribution through Tasmanian wet sclerophyll forests, as forest type may only be a crude indicator of suitable habitat for *T. rodwayi.* Forests with these characteristics appear to be far more widespread and common than *T. rodwayi,* which suggests that other more specific habitat factors or dispersal ability are the controlling factors for its distribution. A similar situation occurs in Victoria, with apparently suitable habitat being much more common than records of the species (N. Walsh, pers. comm.).

Thismia rodwayi has been encountered very infrequently since its original collection in 1890, despite an extensive botanical collecting history in Tasmania (Buchanan 1988), and numerous botanical surveys of Tasmania in recent decades (e.g., Kirkpatrick *et al.* 1988, North *et al.* 1998, and numerous (mainly unpublished) surveys of wet forest areas across a range of tenures). We feel that the current range of the species will not be much expanded without intensive surveys, although we consider that it is likely to be more widespread in Tasmania's wetter forests than current records suggest. The species is distinctive, but by no means obvious, and is likely to continue to be unrecorded in routine botanical surveys. The most likely source of new records for *T. rodwayi* will be from either targeted surveys or from chance encounters by leaf litter researchers. Of the several scientists working on leaf litter species (mostly invertebrates) who were contacted regarding *T. rodwayi* during this study, only one responded with a possible sighting. The lack of chance encounters by researchers who frequently search suitable habitat suggests that the species may be very patchy in its distribution, or that the plants are geographically transient. This latter supposition is supported by Victorian observations in which the species has not been recorded every year from the same known site (N. Walsh, pers. comm.). Von Mueller pointed to the difficulty in finding specimens of this species suggesting that "each flower must be very ephemerous and perishable, and falls probably also quickly to the prey of various insects ..." (von Mueller 1890a: 233).

Leaf litter composition and thickness are likely to be important habitat variables for *T. rodwayi,* given its saprophytic means of nutrition. The composition of the leaf litter on sites supporting the species varied but the moisture content and thickness seemed fairly consistent. The upper layer of leaves was sometimes quite dry but the layer just above the soil was typically damp, dense and cohesive.

Soil and geology are also potentially limiting factors for *T. rodwayi.* The soil where the species was found was generally loamy clay, ranging from quite friable to dense and compacted. Dolerite (or dolerite talus) was the underlying geology of most sites, but this may simply reflect the intensive sampling in the Meander area, which is largely underlain by Jurassic dolerite. The Little Denison River site and Lenah Valley site (table 1) are both on Permian mudstone, suggesting that geology may not be a crucial habitat factor. This is further supported by the knowledge that the species occurs in New Zealand and mainland Australian states, where there is little or no Jurassic dolerite.

The two re-inspections of known *T. rodwayi* sites in January and February, together with historical records, indicate the likely flowering period of the species in Tasmania is October to December. It is possible that the exceptionally dry conditions experienced statewide in January and February 2003 shortened the flowering period for *Thismia* in this year. It is also possible that the flowering of *Thismia* in the summer of 2002–2003 was influenced, perhaps even triggered, by the atypically high rainfall of the previous summer. The timing and duration of flowering, and the effect of seasonal variations in climatic factors such as the amount of rainfall, clearly require further study.

The pollination mechanism of *T. rodwayi* remains poorly understood. Possible pollinators include invertebrates, mammals and lizards. The reproductive biology of other species of *Thismia* is also speculative. Thiele & Jordan (2002) suggest the flower structure of *T. rodwayi* and *T. clavarioides* resembles that of orchids pollinated by fungus gnats, and that an insect pollinator may be constrained once inside the flower, and be forced to leave via the gaps between anther filaments. An animal vector is a possible means of seed dispersal. Mammals such as the potoroo (*Potorous tridactylus* Kerr) are known to feed on orchid tubers and subterranean fungi in similar forest habitats (Claridge *et al.* 1992) and may act as vectors for *Thismia.* Whether other animals may be involved is a matter of conjecture but it is interesting to note that the forest floor in the Glen Huon area (near the southern Tasmanian records of *T. rodwayi*) is extensively disturbed by non-indigenous lyrebirds, *Menura novaehollandiae* Latham (F. Duncan, pers. obs.).

There are clearly many aspects of the reproductive biology of *Thismia* that require further research. However, the

above comments suggest that pollen is transported only short distances (less than 1 km, possibly only metres), and seeds are also dispersed locally. The subterranean flowering and fruiting of *Thismia* may provide serious limitations to cross-pollination and seed dispersal and hence prevent the species from occupying its climatic and habitat potential. In this case, localised populations would be expected, rather than a widespread distribution in suitable wet forest habitat. At any rate, its clumped distribution indicates that the species has very limited ability to disperse seed or reproductive structures.

Response to disturbance

Despite limited records of *Thismia rodwayi* in Tasmania, it is possible to speculate on its response to disturbance. Most records in the Meander area are from either selectively logged forests (in the 1950s, 1960s and 1980s) or from forests subject to more intensive forestry activities such as clearfelling and regeneration burns (at least one site was clearfelled in 1985). Almost all sites in the present study have been burnt at some stage, including the clearfelled sites. Some of the Meander sites may have been protected from high intensity fires associated with forestry regeneration burns or wildfires, as they were on the edge of coupes or in protected gullies. However, sites in the Glen Huon area and on the lower slopes of Mount Wellington were subject to severe wildfires in 1967, and now support regrowth wet sclerophyll forest.

We suggest that maintenance of populations of *T. rodwayi* can be compatible with typical native forest silviculture practised in Tasmanian wet eucalypt forests. However, further evidence from more sites subject to different practices in native forest, and from before-after disturbance event comparisons, would be needed before firm conclusions can be drawn. We consider that *T. rodwayi* would be adversely affected by conversion of wet eucalypt forest to plantation because of the dramatic, and often permanent, changes in site characteristics. Such conversion has occurred extensively in areas with the potential to support *T. rodwayi* (including the base of the Western Tiers, upper Derwent Valley and Franklin area). General observations of many intensively managed forestry sites indicate that a dense broad-leaved shrub understorey and suitable litter layer may not develop in a typical rotation period or under typical plantation management practices.

Reservation Status

Thismia rodwayi is now known from 23 sites in Tasmania (including historical sites cited in this paper); most sites are on public land. The exact location of Rodway's 1890 site is not known but is likely to be on public land that is now part of Wellington Park. Four of the records on public land are located in gazetted reserves (Jackeys Creek Forest Reserve, Wellington Park, Mount Field National Park). A further four are protected by management prescriptions, such as streamside reserves applied under the *Forest Practices Code* (Anon 2000), or other areas excluded from forestry operations under Forestry Tasmania's Management Decision Classification (MDC) system (Orr & Gerrand 1998). Eleven records are on unreserved State forest; seven of these are in, or adjacent to, a single coupe on Archers Sugarloaf, and probably represent one or two populations. Most of these sites will also be excluded from forestry operations, and most are candidates for informal reservation through the MDC system.

Conservation Status

As noted, *Thismia rodwayi* is listed on Schedule 5 (Rare) of the Tasmanian *Threatened Species Protection Act 1995*. Considering that the species was known from only three records when the Act was promulgated, and that few population data were available, a listing that reflected a higher level of threat was probably warranted. The additional distribution and population data provided by this study allow the conservation status of the species to be assessed using the Threatened Species Unit's Conservation Status Assessment Program. However, there is still a lack of data concerning population stability and potential threats. The fact that *T. rodwayi* has now been found in areas known to have been disturbed by fire, clearfelling or selective logging (and in some cases both fire and logging) in the past 50 years suggests these are not highly threatening processes. The suitability of areas managed as native forest through successive rotations is not known. In the absence of further data concerning threats, *T. rodwayi* cannot be confidently listed as either endangered or vulnerable (guidelines for listing: DPIWE 2002). However, the small number, extent and size of known populations suggest a stochastic risk, and it fulfils three of the category 'B' criteria for listing as a rare species (table 5, DPIWE 2002). The species may also fit into category 'A' (DPIWE 2002) on the grounds of populations being small and localised, though this category only applies when an ongoing process is known to be pushing the species into a higher extinction risk category.

It is clear from the comments in table 5 that the species satisfies criteria for being listed as 'rare' based on very conservative estimates of population size and extent. The unconfirmed record from the Ben Lomond region has not been included in this assessment, but this single record would not prevent its qualification as rare under criterion B. There is a high likelihood that more populations exist because the typical habitat of the species is widespread and common in Tasmania. However, the cryptic nature of the species necessitates a precautionary approach. Long-term monitoring of population size and distribution is likely to be logistically difficult for this species, but such work would provide valuable data on potential threatening processes, such as conversion of wet eucalypt forests to plantation or other land use.

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TABLE 5
The criteria for 'rare' (Schedule 5) satisfied by *Thismia rodwayi*

Criteria[1]	Comments
B. Extent of occurrence <2000sq km	Extends from the Meander area in the central north, to Mt Field in the central south (about 120 km), southeast to the Glen Huon area (about 50 km), and to the Hobart area (about 40 km). The total extent of occurrence is approximately 670 sq km.
B. Area of occupancy <50ha	The clumped and patchy distribution of *Thismia* suggests that the actual area occupied by the species at each site is small, even when clumps are spread out. It is therefore unlikely that it occupies even a single hectare at each site. The total area of occupancy is estimated to be less than 20 ha.
B. Most mature individuals in <10 populations	If a record of *Thismia* is considered a distinct population when more than 500 m from any other record and suitable habitat is not continuous, 90% of individuals occur in just four populations (all in the Meander area).

[1] The criteria are taken from a pamphlet produce by the Threatened Species Unit (DPIWE 2002).

the Neika site. The maps were created with the assistance of Gerald Coombe (Forestry Tasmania) and the photo was taken by Hans and Annie Wapstra. Two referees provided useful comments on the manuscript.

REFERENCES

ANON., 2000: *Forest Practices Code.* Forest Practices Board, Hobart.

BUCHANAN, A. M., 1988: *The Tasmanian Collecting Localities of Ronald Gunn and Joseph Milligan.* Tasmanian Herbarium Occasional Publication No. 1, Tasmanian Museum and Art Gallery, Hobart.

CAMPBELL, E. O., 1968: An investigation of *Thismia rodwayi* F. Muell. And its associated fungus. *Transactions of the Royal Society of New Zealand* 3 (14): 209–219.

CCRPL, 2002: Clarence Catchment Rare Plant List (accessed 23 December 2002) <http://www.nor.com.au/environment/clarencecatchment/vegetation/rares/rarelist.htm>.

CLARIDGE, A. W., TANTON, M. T., SEEBECK, J. H., CORK, S.J. & CUNNINGHAM, R.B., 1992: Establishment of ectomycorrhizae on the roots of two species of *Eucalyptus* from fungal spores contained in the faeces of the long-nosed potoroo (*Potorous tridactylus*). *Australian Journal of Ecology* 17: 207–17.

COLEMAN, D. G., 1936: *Sarcosiphon rodwayi* in Australia. *The Victorian Naturalist* 52: 163–166.

COLEMAN, D. G., 1941: Further notes on "fairy lanterns". *The Victorian Naturalist* 57: 167–168.

CONN, B. J., 1994: Burmanniaceae. *In* Walsh, N. G. & Entwisle, T. J. (Eds): *Flora of Victoria. Volume 2.* Inkata Press, Melbourne.

CRIBB, A. B., 1995: The saprophytic flowering plant, *Thismia yorkensis* sp. nov., from Australia. *Queensland Naturalist* 33 (3–4): 51–56.

CURTIS, W. M. & MORRIS, D. I., 1994: *The Student's Flora of Tasmania Part 4b Angiospermae: Alismataceae to Burmanniaceae.* St David's Park Publishing, Hobart.

DPIWE, 2002: *Guidelines for the Listing of Species Under the Tasmanian* Threatened Species Protection Act 1995. Information brochure produced by the Department of Primary Industries, Water and Environment, Tasmania.

JONKER, F. P., 1938: A monograph of the Burmanniaceae. *Mededeelingen van het Botanisch Museum en Herbarium van de Rijks Universiteit te Utrecht* 51: 1–279.

KIRKPATRICK, J. B., PEACOCK, R. J., CULLEN, P. J. & NEYLAND, M. G., 1988: *The Wet Eucalypt Forests of Tasmania.* Tasmanian Conservation Trust Inc., Hobart.

MCCLENNAN, E. L., 1958: *Thismia rodwayi* F. Muell. and its endophyte. *Australian Journal of Botany* 6: 25–37.

MOORE, L. B. & EDGAR, E., 1976: *Flora of New Zealand Volume II.* Government Printer, Wellington.

NORTH, A., JOHNSON, K., ZIEGLER, K., DUNCAN, F., HOPKINS, K., ZIEGELER, D. & WATTS, S., 1998: *Flora of Recommended Areas for Protection and Forest Reserves in Tasmania.* Forest Practices Board, Forestry Tasmania, and Parks and Wildlife Service, Tasmania.

ORCHARD, A.E., 1988: A natural regions map for Tasmania. *Papers and Proceedings of the Royal Society of Tasmania* 122 (2): 47–51.

ORR, S. & GERRAND, A.M., 1998: Management Decision Classification: a system for zoning land managed by Forestry Tasmania. *Tasforests* 10: 1–14.

RODWAY, L., 1903. *The Tasmanian Flora.* Government Printer, Hobart.

THIELE, K. R. & JORDAN, P., 2002: *Thismia clavarioides* (*Thismia*ceae), a new species of Fairy Lantern from New South Wales. *Telopea* 9(4): 765–771.

VON MUELLER, F., 1890a: Notes on a new Tasmanian plant of the order Burmanniaceae. *Proceedings of the Royal Society of Tasmania* 1890-1891: 232–235.

VON MUELLER, F., 1890b: Descriptions of new Australian plants, with other annotations. *The Victorian Naturalist* 8: 114–116.

WILLIS, J. H., 1970: *A Handbook to Plants in Victoria Volume I: Ferns, Conifers and Monocotyledons.* Melbourne University Press, Carlton, Victoria.

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APPENDIX 1

Register of all known *Thismia rodwayi* sites from Tasmania (including records from this study, DPIWE's GTSpot database and Tasmanian Herbarium (HO) records)

Date	Site[1]	Recorder[2]	Easting - Northing[3] Latitude - Longitude[4]	Altitude (m)	Geology	Forest type[5]	No.	HO no.	Precision[6]
Dec.1890[9]	Cascades, Hobart[7]	L. Rodway	523800mE 5249300mN 42°54'S 147°17'E	290				25468	2
Nov.1923	Mt Field Track (Mt Dobson Rd)	L. Rodway	476100mE 5273400mN 42°41'S 146°42'E	300				23812	2
1968	Link Road between Russell River Road and Little Denison River[8]	B. Reid	481700mE 5241900mN 42°58'S 146°46'E	120				115634	2
20/10/68	Little Denison River via Judbury[8]	B. Reid & W.M. Curtis	481700mE 5241900mN 42°58'S 146°46'E	120				51377	2
?1980s	Ben Lomond region[10]	Unknown	560000mE 5420000mN						5
?1980s	Neika area	R. Jones	518750mE 5244700mN	400					1
01/11/02	Lenah Valley fire track	S. McMullen-Fisher	521350mE 5352150mN 42°52'S 147°15'E	320	Dolerite	WET-REG 1001		519153	1
15/11/02	Archers Sugarloaf	N. Fitzgerald (this study)	467940mE 5387408mN 41°39'S 146°36'E	415	Dolerite	WET-OB010	3	519512	1
15/11/02	Archers Sugarloaf	N. Fitzgerald (this study)	467647mE 5387340mN 41°39'S 146°36'E	425	Dolerite	WET-OB0110	5	519510	1
15/11/02	Archers Sugarloaf	N. Fitzgerald (this study)	467621mE 5387245mN 41°39'S 146°36'E	436	Dolerite	WET OB0110	3	519511	1
09/12/02	Archers Sugarloaf	this study	468008mE 5386663mN	445	Dolerite	WET OB0110	3		1
09/12/02	Archers Sugarloaf	F. Duncan (this study)	468500mE 5387020mN 41°40'S 146°37'E	405	Dolerite	WET OB0110	39	521462	1
10/12/02	Archers Sugarloaf	this study	467597mE 5387160mN	435	Dolerite	WET OB0110	2		1
10/12/02	Archers Sugarloaf	this study	467759mE 5387242mN	430	Dolerite	WET OB0110	1		1
10/12/02	Warners Sugarloaf	N. Roberts (this study)	470277mE 5386284mN 41°40'S 146°38'E	450	Dolerite	WET OB0110	5	521463	1
10/12/02	Jackeys Creek FR	this study	470474mE 5386494mN	440	Permian mudstone	WET VIM-0011	13		1
11/12/02	Warners Sugarloaf	N. Roberts (this study)	469875mE 5385927mN 41°40'S 146°38'E	435	Dolerite	WET DEL0100	3	521464	1
11/12/02	Meander River	M. Wapstra (this study)	463447mE 5381741mN 41°42'S 146°33'E	510	Dolerite talus	WET-DEL1000	5	521468	1
11/12/02	Meander River	this study	461997mE 5380691mN	590	Dolerite talus	WET-DEL0110	18		1
11/12/02	East of Meander River	M. Wapstra (this study)	462859mE 5380724mN 41°43'S 146°33'E	610	Dolerite talus	WET-DEL0111	7	521465	1
11/12/02	Meander River	this study	463980mE 5382231mN	465	Dolerite talus	WET-DEL0111	3		1
18/12/02	New Rd, Franklin	N. Roberts (this study)	495197mE 5230445mN 41°04'S 146°56'E	435	Dolerite	WET DEL0110	5	521466	1
18/12/02	New Rd, Franklin	this study	495195mE 5230252mN	440	Dolerite	WET DEL0110	2		1
18/12/02	Blue Gum Hill, Glen Huon	N. Roberts (this study)	491200mE 5232900mN 41°03'S 146°33'E	470	Dolerite	WET-REG1001	5	521467	1

[1] For records with supporting specimens in HO, the locality is listed as it appears on the herbarium sheet.
[2] For records with supporting specimens in HO, only the first collector listed on the herbarium sheet is shown.
[3] All grid references are in AMG66 coordinate system.
[4] For records with supporting specimens in HO, the latitude/longitude recorded by HO is included.
[5] Forest type code is taken from North *et al.* (1998).
[6] Precision codes: 1 (precise to within 50 m radius (or nearest second) e.g., GPS reading or 6-figure grid reference); 2 (falling within a 1 km radius (or nearest minute) e.g., a location able to be accurately pinpointed on a map such as the name of a hill; 5 (greater than 25 km radius) e.g., location given as a region, rather than point locality.
[7] Specimens from the same site are also held at National Herbarium of Victoria (type specimen) with duplicates at Royal Botanic Gardens, Kew and Botanischer Garten und Botanisches Museum, Berlin-Dahlem.
[8] Specimens from the same site but held on different herbarium sheets.
[9] The specimen at HO has a date of Dec 1890, but specimens in National Herbarium of Victoria are dated 16/11/1890.
[10] Precise locality not known but identification confirmed by HO (see text for details).

THE ANTIQUARIAN MIND: TASMANIAN HISTORY AND THE ROYAL SOCIETY OF TASMANIA 1899–1927

by Stefan Petrow

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Between 1899 and 1904, and again between 1921 and 1927, enthusiasts of Tasmanian history formed the Historical Section of the Royal Society of Tasmania. They sought to highlight Tasmania's rich historical traditions. They were especially interested in the deeds of foundation heroes such as explorers, governors and pioneers, but tended to ignore convict and Aboriginal history. They sought to preserve historical documents, save existing monuments and erect new monuments to their heroes, celebrate key events in Tasmania's past, and ensure places were given suitably historical names. They held lectures and published papers on their favourite aspects of Tasmanian history. They believed that history could teach valuable lessons if properly studied. This paper considers the activities of history enthusiasts in Hobart and Launceston and concludes that in small ways these enthusiasts contributed to an understanding of Tasmania's past and helped to create a public awareness of early Tasmanian achievements.

Key Words: commemoration, historical documents, historical consciousness, memorials, Royal Society of Tasmania, Tasmanian history.

INTRODUCTION

The English have long been fascinated with their past (Hey 1996). A tradition of antiquarian writing can be traced back to the Middle Ages when topographical descriptions were allied with the study of genealogy and heraldry. In the sixteenth century antiquarian studies became more firmly established and the study of manuscript material became common. The evidence of ruins, relics, coins and other non-literary sources were also consulted. In the seventeenth century the study of natural history became more popular and there was a growing interest in urban history. The antiquarian tradition flowered in the nineteenth century with the publication of numerous substantial works and the formation of record societies all over England (Levine 1986). Most of the members of these societies were untrained middle-class male elites, who were bent on recreating the English past as a source of local and national pride. As Levine has noted, Victorians revered "the home, both as a symbol of the domestic ideal and as a homeland" and this feeling "found an outlet in the national pride of the antiquarian community" (Levine 1986: 74). The antiquarian felt he had a duty to preserve information for posterity. Notable developments included the creation of the Public Record Office in 1838, the Royal Commission on Historical Manuscripts in 1869 and the British Record Society in 1888 (Hey 1996).

Drawing on an older tradition of county histories, in 1899 the monumental, multi-volumed series *The Victoria History of the Counties of England* was launched as a memorial to the achievements of Queen Victoria. It was conceived as "a scholarly and comprehensive encyclopaedia of English local history in all periods, a repository of essential information and the starting point for further research" (Hey 1996: 473). The general volumes comprised natural history, pre-history, the Roman and Anglo-Saxon periods, the Domesday Book, political and administrative history, ecclesiastical history and religious houses, social and economic history, forests, endowed schools and sport (Pugh 1970). The topographical volumes were divided into parishes, townships and towns. In the towns the subjects studied included manors and other estates, economic history, local government, church, Nonconformity, education and charities for the poor. After promising much, the venture fell into abeyance from 1910 until it was revived in 1933.

The desire to preserve the past and recreate past glories was the impetus behind the formation of historical societies in late nineteenth-century Australia (Garden 1998). The first historical society was the Historical Society of Australasia formed in Melbourne in 1885 but this folded in 1886. The Australian Historical Records Society was active in Ballarat from 1896 to 1906. State historical societies were the product of the twentieth century: in New South Wales the Australian Historical Society was formed in 1901; the Historical Society of Victoria, 1909; the Historical Society of Queensland, 1913; the Western Australian Historical Society and South Australian Historical Society, 1926.

In Tasmania no separate historical society was founded before 1930 and interest in local history was confined to a section of the Royal Society of Tasmania, the leading scientific and cultural institution. First established in 1843, the Royal Society of Tasmania is Australia's oldest scientific society. Initially formed "to develop the physical character of the Island, and illustrate its natural history and productions", in 1907 its aim was broadened to include "the prosecution of the study of science in its various branches"; in 1914 the aim was further extended to become "the advancement of knowledge" for the benefit of Tasmania (Pearson 1943: 224–226, Somerville 1943). Various sections brought together members with similar interests: the major sections included Botany, Zoology and Geology, as well as Palaeontology and Anthropology. Another, less well-known section was History and Geography. This section pioneered the study of Tasmanian history well before it made an appearance at the University of Tasmania, where Australian history was taught as a small part of British history and Tasmanian history was ignored until well after the Second World War (Macintyre 1992). From a survey of royal societies in other states, it appears that no history sections were formed, but at times lectures were given on historical topics (Maiden 1918, Madigan 1936).

The interest in Tasmanian history can be attributed to the energy of a small group of enthusiasts, who followed

the lines of antiquarian enquiry adopted by historical societies in England and the other Australian states. These enthusiasts came from the professional classes and their interest was driven by curiosity and love of place and was not "the product of community feeling" (Fletcher 1993: ix, 55). As Griffiths (1996: 1) notes of the growth of historical consciousness in other states, this antiquarian imagination was "a historical sensibility particularly attuned to the material evidence of the past, and possessing a powerful sense of place". As Davison (1988: 67) has argued, antiquarians do not seek "to transcend the past, but to preserve it, to re-enter it, and, if necessary, to recreate it". They were especially interested in memorials and monuments, which represented the achievements of foundation heroes, notably explorers and governors (Ashton & Hamilton 2000). The achievements of these heroes would serve as an inspiration to the younger generation (Fletcher 1993: 119).

Like history enthusiasts elsewhere, members of the Historical Section of the Royal Society wanted to record the memories and achievements of the pioneer generations for posterity (Davison 2000). Their view of history was "triumphant", to celebrate the "territory gained, settled and subdued" (Davison 2000: 200). They emphasised the first time an area had been discovered or explored as a reflection of "the genealogy of communities still striving to establish a sense of legitimacy in newly settled land". They tended to ignore, where they did not lament, the dark deeds of the past such as the killing of Aborigines or the brutality of the convict system. The convict taint still preoccupied the minds of many citizens and historians had to handle the subject with care.

We can consider the activities of the historical section in two phases. The first phase, between 1899 and 1904, was Hobart-centred and limited in achievement and the second phase, between 1921 and 1927, saw historical consciousness spread to Launceston as well and had a greater impact in various ways.

PHASE 1: 1899–1904

In May 1899 the Historical and Geographical Section of the Royal Society of Tasmania was established (RSA/H/5). It aimed to provide Fellows of the Royal Society interested in those disciplines with a chance to meet outside the monthly meetings of the society and, above all, to promote historical and geographical research into Tasmanian subjects. The driving force behind this move was the Anglican Bishop of Tasmania, Henry Hutchinson Montgomery, who became the first President of the section. The Vice-Presidents were the lawyer, James Backhouse Walker, and the photographer, John Watt Beattie. The committee members were the Surveyor-General, Edward Albert Counsel, the Government Statistician, Robert Mackenzie Johnston, the sanitarian, Alfred Mault, the dentist and Government Botanist, Leonard Rodway, the educationalist, Thomas Stephens, and the Anglican cleric, J.B.W. Woolnough. Professor William Jethro Brown was Treasurer and museum curator, Alexander Morton was Secretary.

The geographical element was best represented by Counsel (Elias 1981), Johnston (Wettenhall 1983), Mault (Anon. 1974), Rodway (Elias 1988) and Stephens (Smith 1976). Walker was renowned for his research into early Tasmanian history (Walker 1973). In 1884 he had toyed with the idea of forming a Tasmanian branch of the Historical Society of Australasia, but nothing came of this (W9/C9/1). Walker thought the object of the new section should be "to gather materials for the history of Tasmania" and stop the flow of records from the island (PPRST 1898–1899: xxv). Showing an early knowledge of social history, he had a strong interest in "the growth and development of communities" and the history of the "nameless crowd" and believed history could teach valuable lessons if used correctly (*The Tasmanian Mail*, 26 October 1889). Beattie accumulated a museum of art and artefacts of local history, developing a special interest in convict and Aboriginal history (Roe 1979). Brown taught history as well as law at the University of Tasmania (Roe 1977) and Morton, although more interested in natural history, had begun to collect historical items for the Tasmanian Museum and Art Gallery (Huxley 2002). Woolnough's interests are unclear.

Montgomery, in the tradition of the scholar-parson with an interest in natural and local history, provided the clearest rationale for forming the section (Hey 1996). The section would concentrate on "local research; everything that bears upon the history of Tasmania will be its object", but not the history of other colonies or England, although he realised that the line could not be drawn too sharply (*Tasmanian News*, 20 May 1899). The section should aim "to conserve facts which will be of immense interest" in two centuries even if they may seem "trivial" now. Montgomery was inspired by the recent decision to begin "a fresh set" of county histories in England. He was also known as "the layman's Bishop" because he showed a real interest in all aspects of Tasmanian life and often asked about local history on his incessant perambulations around the state (*Tasmanian News*, 21 October 1901).

Montgomery suggested various ways in which the section could do "valuable work" (*Tasmanian News*, 20 May 1899). It should tabulate and preserve government papers languishing in government store rooms before they were destroyed or became unusable. It should acquire "old maps" from government and private sources as well as sketches, photographs and plans of Tasmanian places. Montgomery thought biography had "extreme value" in showing "the manner of life and the early difficulties". It should acquire portraits and diaries of prominent settlers and ask "all our aged friends" to record their reminiscences, especially "highly respected and venerated" members like James Agnew, Charles Butler and B.T. Solly. He thought anyone who had lived in the colony for 30 years should record his or her memories. Montgomery had already recorded his reminiscences for the benefit of his own family and he advocated study of the prospectors and pioneers of the West Coast before they died. He also referred to another neglected region of Tasmania — the King, Flinders and Barren islands, whose residents had much to tell. These islands contained the descendants of Tasmanian Aborigines, but Montgomery, although a frequent visitor, did not spell this out (Ryan 1981).

The next suggestion was to secure a collection of autograph letters of "prominent men" (*Tasmanian News*, 20 May 1899). Following an idea raised by *The Mercury*, Montgomery thought that a history of Hobart should be written. He advocated contacting all the municipalities and enlisting their help in gaining information about the reminiscences, diaries, pictures and maps in their districts. He also wanted to fill the gaps on Tasmanian history in the Royal Society library before valuable books were "carried away" to the other colonies. Finally, the Historical Section should ask

government for "some additional spacious rooms in which to house the treasures" it would collect.

This ambitious programme was followed up by lectures. At the first meeting on 29 June 1899 Montgomery read a paper on journeys westward by W.S. Sharland in 1832 and John Franklin in 1842 (*Tasmanian News*, 30 June 1899). He urged members to prepare a map of the "unexplored or nearly unexplored" parts of Tasmania, which would provide an outlet for their "romantic spirits" and attract those tourists who saw themselves as "discoverers". At the next meeting, held on 1 August, Walker spoke about "The Cartography of the Terra Australia and New Holland" and Johnston gave an account of Macquarie Harbour meteorology and tides in 1825–1826 (*The Mercury*, 2 August 1899). In subsequent years further papers were given, such as Mault's on "Hobart Society in 1845", based on the journal of a French lady (*The Mercury*, 20 September 1900).

Documentary material was an early focus. In August 1899 Montgomery wrote to Premier Edward Braddon about James Bonwick's 20 volumes of transcriptions of Tasmanian official papers in the English Public Record Office (RSA/H/5). This "mass of official information" was essential to anyone writing a history of Tasmania, and Montgomery wanted the government to place it in the "safe custody" of the Royal Society. He claimed that the Royal Society in part existed "to *prepare* and *conserve* materials for the History of our colony from all points of view" and could "almost" be called "the Society for the Preservation of Historical Records". Any records it was given or acquired would not leave its premises, but would be open to bona fide researchers. However, Braddon and his colleagues believed that all "state documents" should be kept in the government archives and could not agree to Montgomery's request.

Thereafter the activities of the section slowed down. One reason for this was the death of James Backhouse Walker in November 1899. All bemoaned the loss of this "leading authority" on Tasmanian history (*The Mercury*, 4 and 6 November 1899). A sermon given by his friend, the Reverend George Clarke, noted that Walker took "infinite pains to verify the facts" in his quest "to get at the exact truth of things" (*The Mercury*, 13 November 1899). His historical work was done "for no personal gain or reward": it was a labour of love (RSA/H/5). Then in May 1900 Brown left for England (Roe 1977). The decisive blow was struck in November 1901 when Montgomery left the state. An address from the Royal Society lauded his promotion of research work on early Tasmanian history, especially the early explorers and the Aborigines (*The Mercury*, 7 November 1901). He left his historical paintings and books to the society.

According to up-and-coming bureaucrat and local historian John Reynolds (1966), the Historical Section continued on until 1914, but he produced no evidence to support this claim. Certainly, some Royal Society members retained their interest in history and historical papers were given, but the activities of the section seemed to have waned after Montgomery's departure (RSA/H/3). If the section had been active, then it surely would have been prominent in the celebrations of Tasmania's centenary in September 1903 and February 1904. The only member of the Historical Section to sit on the Centenary Committee was its Secretary, Alexander Morton (*Tasmanian News*, 19 February 1904). The September celebrations were limited to a "quiet" affair organised by the City Council in Hobart in deference to the tragic smallpox epidemic that had hit Launceston (*Tasmanian News*, 12 September 1903). Another possible reason was Premier W.B. Propsting's convict ancestry (Roe 2001). Although *The Mercury* (12 September 1903) published 20 pages on Tasmanian history (very little on the convicts), none of the articles was attributed to a member of the Historical Section. The *Tasmanian News* (12 September 1903) historical overview was written by Caroline Morton, Alexander's wife.

The February 1904 celebrations were more obvious and lasted longer, but were still limited to Hobart (Roe 2001). Northerners did not take an active part, but were with their "southern friends in spirit in their efforts to commemorate a noteworthy historic event" (*The Examiner*, 24 February 1904). This time one of the members of the Historical Section was prominent. John Beattie opened proceedings with two lectures called "Glimpses of the Lives and Times of the Early Tasmanian Governors" (*Tasmanian News*, 19 February 1904; *The Mercury*, 22 February 1904). In introducing Beattie, the Chief Justice, Sir John Dodds, said no one was better qualified than Beattie to lecture on Tasmanian history. His painstaking examination of archival records had unearthed much knowledge, "which must prove worthy of being remembered and which, but for him, would have been forgotten". Moreover, he had explored all parts of Tasmania and presented 700 photographs to the government. Apart from Beattie, the Royal Society Historical Section seems to have played no part in the celebrations, even at the unveiling of a memorial stone at Risdon, the other major historical event of February 1904 (*Tasmanian News*, 23 February 1904). *The Tasmanian Mail* (20 February 1904) produced a centenary supplement giving a solid overview of Tasmanian history, but no member of the Historical Section seems to have contributed.

The muted centenary celebrations of September and February indicated that Tasmanians were not yet fully ready to embrace their history (Roe 2001). Newspaper reflections on the past pointed in the same direction. Take *The Mercury* (12 September 1903) as one example. Tasmania had made satisfactory if slow progress in the past one hundred years and had overcome a "blundering" foundation by Bowen "to grow into a fair State in which peace, order, law, and general prosperity" prevailed. But the strong impression created by the newspapers was, as expressed by *The Mercury*, that Tasmania's dark past of "cruel suffering and many woes, amid scenes which, even now, we may shudder to recall", such as the treatment of convicts and the "destruction" of the Aborigines, should be forgotten and all should look to a brighter future. Tasmanians were better at forgetting than remembering and looked to the future not to the past. As Launceston's *Daily Telegraph* (12 September 1903) put it, the thought of the day was "forward rather than backward" and people cared little for precedent. Thus in its first phase the Historical Section had little impact and generated little interest either before or after the centenary celebrations.

PHASE 2: 1921–1927

Hobart

The Historical Section was revived by J. Moore-Robinson. Born in Dublin in the early 1870s, Moore-Robinson fought in the Boer War and settled in Tasmania in the early 1900s, working as a journalist on *The Mercury* (Biskup 1989). In 1912

he became Secretary to the Tasmanian Tourist Association, but was dismissed in 1914 after being implicated in mismanagement of the association's finances. In 1916, with university lecturer Herbert Heaton, he revived the Historical Section as the Australian History and Economic Section, but the revival was brief (Somerville 1943). In 1916, Moore-Robinson volunteered to fight in the First World War and stayed until his discharge in February 1919; Heaton left Tasmania in 1917 (Bourke 1983). In January 1920, Moore-Robinson was appointed to the new position of librarian and publicity officer in the Chief Secretary's Department with special responsibility for government records and newspapers stored in the vaults of the Supreme Court building in Franklin Square.

While on a tour of Melbourne and Sydney libraries, Moore-Robinson met leading historians Professor George Arnold Wood of the University of Sydney and Dr Frederick Watson, editor of the *Historical Records of Australia*, which aimed to make official primary records of Australian history accessible to historians (Biskup 1989). Watson visited Tasmania in late 1920 and, excited by the virgin field of Tasmanian history and Moore-Robinson's zeal, secured for the Tasmanian Government a Commonwealth grant of £500 to index and arrange Tasmanian historical records. This was an important impetus behind the revival of interest in Tasmanian history and Moore-Robinson became "Tasmania's as well as Australia's" first part-time archivist (Biskup 1989:49). He did much good work until an economy drive forced his dismissal in September 1925, whereupon he began a flax-processing company, but never lost his interest in Tasmanian history. The glaring blot on Moore-Robinson's career was the evidence, accumulated in the early 1960s, that he trafficked in Tasmanian records for personal gain (Biskup 1989).

In early 1921, Moore-Robinson became joint secretary, with University of Tasmania history lecturer Charles King, of the Geography and History Section of the Australasian Association for the Advancement of Science (Biskup 1989). At its conference he gave a paper on early Tasmanian records and stressed the importance of preserving and using the voluminous records held in the Chief Secretary's Department (*The Mercury*, 29 January 1921). This appears to have been the first systematic account of Tasmania's official records. To stimulate an interest in the island's history, a revised version of the lecture was given at the August meeting of the Royal Society (Moore-Robinson 1921). Moore-Robinson thought history was useful in providing "examples for present and future effort. By taking heed of its lessons, errors may be avoided, and individual and national efforts rightly directed" (*The Mercury*, 5 July 1924, supplement).

In July 1921, Moore-Robinson asked the Royal Society Council for authority to revive the Australian History, Geography and Ethnology section (RSA/H/3). He had a "legitimate hope" that members would produce historical work of the "illustrious" standard achieved by Walker and Beattie who, with King and others, supported the proposal. In a press release Moore-Robinson noted that Tasmanian history had been sadly neglected and suggested that early constitutional history, banking, shipping, religion and "the sad story of the decline and disappearance of the Tasmanian aborigines" all warranted "historical investigation". He hoped that the section could collect historical facts for future students, who would "collate the facts into a collected historical narrative" (RSA/H/3).

In September 1921 the section was re-established, with lawyer W.F.D. Butler as President and Moore-Robinson as Secretary (RSA/H/1). Moore-Robinson remained Secretary until he resigned in June 1923 due to the pressure of his government work for the British Empire Exhibition (RSA/H/1; RSA/H/3). He was succeeded by John Reynolds, who praised Moore-Robinson for stimulating "a much more intelligent interest in our local history" (RSA/H/3). Reynolds continued as Secretary until December 1927 when pressure of work and a move some distance from Hobart forced him to resign (RSA/H/2). As we will see later in this paper, the section also visited the northern branch of the Royal Society and stimulated interest in early Tasmanian history and the collection of documents (PPRST 1926). The Historical Section secured the support of key members, such as Clive Lord, who was Director of the Tasmanian Museum and Secretary to the Royal Society Council (*The Mercury*, 17 July 1933). Lord had a deep interest in the early history of Tasmania and "in particular the records of the vanished aborigines".

We can consider the work of the Historical Section during this period in a number of areas: preserving and erecting monuments, celebrating key events in Tasmania's past, collecting historical documents, ensuring places were given suitably historical names, and giving lectures and publishing papers on Tasmanian history.

The preservation of monuments was one of the first causes. In 1922 the section became aware that some monuments in St David's cemetery, which had been handed over to the City Council as a park, were deteriorating (RSA/H/3). Governor Eardley Eardley-Wilmot's monument was in "a somewhat deplorable condition" as a principal pillar had broken away and a step was cracking. Apart from any legal obligations arising from the transfer of the cemetery, the section told the Council that the city would be disgraced "if such beautiful historic relics are allowed to suffer undue decay". The section also protested at the Council's plan "to cut out inscriptions" from headstones and set them in concrete at Queenborough Cemetery (RSA/H/1). Finally, in 1924 the Council agreed to the section's suggestion that all important tombstones be placed in the northeast corner of St David's in "a fitting and artistic manner" (RSA/H/1; MCC16/129/22: 343).

The Historical Section also attempted to save other monuments. In 1922 it asked the Scenery Preservation Board to preserve the monument to the convicts who lost their lives when the *George III* convict ship sank in 1835 (RSA/H/3). In 1927 when St George's burial ground was being levelled in order to build Albuera Street School the section suggested to the Director of Education, G.V. Brooks, that the monument to the politician William Race Allison should be saved and re-erected in St David's Park (RSA/H/1; RSA/H/3). Brooks obliged. A grateful Reynolds told him that since 1921 the section had "not experienced such sympathetic co-operation".

Less successful was the campaign to restore the Grecian-inspired Lady Franklin Museum at Lenah Valley. In about April 1921 the local progress association first agitated for the museum to be restored to its original purpose as a botanical or forestry museum and not be used as an apple store (*The Mercury*, 5 September 1923, 20 July 1925). Clive Lord pleaded for public support to save the museum. He regretted "the spirit which allows the history of the past, with the attendant doings of the men and women who made Tasmania what it is to-day, to be overlooked" (*The Mercury*, 16 December 1925). He favoured moving the Lady Franklin Museum to St David's Park and housing in

it Beattie's historical collection, which Tasmania was "in hourly danger of losing for all time". Tourists would be more likely to visit if the museum was in a more central location and it would be a feasible business proposition for the City Council. As the building was too brittle to move, this proposal foundered. Legal and financial entanglements blocked attempts to restore the museum in the 1920s.

The Historical Section sought to erect monuments to prominent explorers and governors. Moore-Robinson encouraged the movement to erect a monument to Abel Tasman at his 1642 landing place (*The World*, 22 January, 9 October, 29 November 1923). By reading Tasman's charts and journal, Moore-Robinson led an expedition, under the auspices of the Royal Society and the State Government, to Prince of Wales Bay on the Forestier Peninsula between 12 and 15 January 1923. The expedition included "experienced official navigators, as well as men possessing intimate knowledge of the coast line, together with weather conditions experienced in the locality". When the expeditioners landed they found the stumps of four old trees in a crescent noted by Tasman in his journal. Although Tasman's charts were vague and landmarks had been obliterated, they concluded that "this indeed was the actual spot on which was made the first identifiable landing of white people, not only in Tasmania, but in Australia. It is indeed historic, if not sacrosanct". They decided that the best site for the memorial was the centre point of Tasman's crescent of trees, about 25 yards above the highwater mark. The concrete memorial was an obelisk 12 feet 6 inches high and 4 feet 6 inches at the base.

At the unveiling ceremony on 3 December 1923, the Administrator Sir Herbert Nicholls, who had first suggested a memorial, said "preservation of historical knowledge is of vast importance" (*The World*, 4 December 1923). The Royal Society deserved praise for "keeping Tasmania's reputation as a place where ...thought, art, poetry and history are regarded as greater than wealth". Nicholls called Tasman "the godfather of this beautiful island". Two weeks later the euphoria was deflated at a meeting of the Royal Society when some members questioned whether the memorial had been placed in the correct position (*The Mercury*, 18 December 1923). Moore-Robinson was incredulous that despite all the publicity and discussion about the memorial it should be disputed after the unveiling and not before. He explained how they arrived at the spot which, he felt convinced, was "as near as possible to the place where Tasman's carpenter landed and planted the flag of his country". Pointing out the difficulties of finding the exact spot, Clive Lord, who contrary to Moore-Robinson had stated his reservations about the site in October 1923 (Reynolds 1966), revisited divergent investigations of Tasman's landing place by the Reverend J.P. Gell and James Backhouse Walker, both of whom differed from the expedition's spot. Lord noted that Tasman recorded that he could see the Dutch flag from his ships but it would have been "impossible to see if planted on the present site of the memorial". Lord believed that the four trees noted by Tasman were 200 yards to the north of the memorial. Arguments sallied to and fro, and uncertainty grew. Finally, the meeting resolved that the inscription on the memorial should be changed from "at this spot" to "near this spot".

This decision did not end the dispute. In December 1925, G.H. Halligan, former hydrographer and supervising engineer to the New South Wales government, stunned a Royal Society meeting by claiming that his investigations indicated that Tasman had landed some two miles southeast from where the memorial had been placed (*The Mercury*, 15 December 1925). Lord thought Halligan was wrong and restated his view that the memorial had been wrongly located. Lord (1926) followed up his assertions on the planting of the Dutch flag in a paper published in the *Papers and Proceedings of the Royal Society.*

Moves to erect other memorials were less contentious. For example, in 1927 the section decided to place a suitable tablet to commemorate Governor David Collins' landing at Sullivan's Cove (RSA/H/1). The most suitable spot was the wall of an ice factory owned by Jones and Company. With the practical and financial support of the company and Lady Jones, the wife of the company's founder, the project was completed. The tablet, which cost £60, read "David Collins landed near this spot Hunter's Island and Founded the City of Hobart on 20 February 1804" (RSA/H/1; PPRST 1927: 232).

The 1920s was a time to celebrate important centenaries. These included the centenary in 1924 of the Supreme Court (*The Mercury*, 9 April 1924) and of the oldest law firm, Butler, McIntyre and Butler (*The Mercury*, 2 July and 23 September 1924); and in 1925 of the Legislative Council (*The Mercury*, 17 July 1925), of the first school (*The Mercury*, 10 December 1925) and of the Richmond Court House (*The Mercury*, 17 and 21 December 1925). The Historical Section seems not to have played a part in these celebrations. It did, however, organise a centenary dinner to commemorate Van Diemen's Land's separation from New South Wales in December 1825 (known popularly as Independence Day) because, noted *The Mercury* (3 December 1925) "an extraordinary apathy, or myopia" had "smitten" the Lyons government about this celebration. One possible reason for official apathy was the death of Queen Alexandra (*The Mercury*, 4 December 1925). At the dinner the president of the Historical Section, W.F.D. Butler, outlined the history of Van Diemen's Land to the declaration of independence (*The Mercury*, 4 December 1925). Other members registered more sombre thoughts. The Chairman of the Royal Society Council, Leonard Rodway, referred to "the extermination of the original owners of the island", the Tasmanian Aborigines, who were "a fine race before the arrival of the white man". He regretted from "a scientific point of view" that the Tasmanian Museum had not collected more Aboriginal exhibits. Dr William Crowther, a compulsive collector and dedicated medical historian, angrily denounced the wilful destruction or removal from the State of so many historical documents and urged that existing records on the Aborigines be "carefully collaborated and preserved".

Although the Historical Section spoke sympathetically about the Aborigines and celebrated some aspects of Tasmania's past, it did have one obvious blind spot. Tasmania's convict past received little attention. This reflected wider community views. For example, in 1921 Tasmanian-born Thomas Dawson told *The Mercury* (29 September 1921) readers that convict buildings should be "turned into churches and packing sheds". Tasmanians could not "feel any pride" in the convict system, which "so ill-used" men that they "almost became brutes". Dawson wanted the name of Port Arthur wiped "off the map". Not everyone agreed (see *The Mercury*, 8 October 1921, letter by "Meataxe" and 22 October 1921, letter by H. Benjafield), but the Historical Section showed a lack of interest or sensitivity to the convict past. In December 1925, William Crowther advocated placing parts of Beattie's

historical collection relating to governors in the Tasmanian Museum, but thought that the Port Arthur relics "might be discarded in their entirety or otherwise disposed of" because they were "a small and the least interesting part of the collection" (*The Mercury*, 23 December 1925).

To be sure some members of the Historical Section did study convict themes. For example, Moore-Robinson wrote about Port Arthur and Lord (a descendant of a convict) wrote about Port Puer, both indicating a growing acceptance of the convict past, but there were limits (Young 1996). The Historical Section's anti-convict bias was most strongly manifested in its reaction to the filming in Tasmania of Marcus Clarke's novel *For the Term of His Natural Life* (Roe 1989). On 9 August 1926, A.N. Lewis moved that the Royal Society thought Clarke's novel did not represent "true history" (*The Mercury*, 10 August 1926). As "the tradition of American cinema producers is contrary to the representation of true history", and as they had shown "only an ability to pervert facts for money-making purposes, this society condemns" the film. It considered the film "to be against the best interests of Tasmania and historical studies", and directed the Council to oppose and discourage the production. Lewis argued that the novel did not portray "what actually happened" at Port Arthur, which in any case played "a very unimportant part" in Tasmanian history. The film would not be "real history" but "a "love" story with a background of man-traps, chain gangs, and other horrors". Lord seconded and Crowther supported the motion. Crowther did not think that the "brutal and degrading" convict past should be allowed "to go on in perpetuity". The Bishop of Tasmania, Dr Robert Snowdon Hay, preferred to see all associations "with the days of penal settlement" in Tasmania "scrapped forever". Chairman Rodway represented those members who thought too much fuss was being made and that the film should have been ignored, but the motion passed by "a small majority". The film went on to become a popular success in Hobart, perhaps revealing an unexpected interest in the darker side of Tasmanian history (Roe 1989).

One key aim of the Historical Section was to uncover the existence of historical documents on Tasmania, take custody of them and make them available to students of Tasmanian history (RSA/H/3). To stimulate interest in "the discovery of historical documents", Moore-Robinson persuaded Dr Frederick Watson, editor of the series *Historical Records of Australia*, to talk on "The Writing of Australian History" (*The Mercury*, 11 October 1921). After Watson's lecture John Beattie described the destruction of past records as "dreadful" and denounced Tasmanian legislators for allowing the records to be "pillaged and destroyed". It is unclear how successful the Historical Section was in securing custody of historical records. We have definite evidence of W.F. Rawnsley donating some Franklin manuscripts, including Lady Franklin's diaries, in 1924 (PPRST 1924) and of the Society acquiring a copy of the Reverend Robert Knopwood's diary in 1926 (PPRST 1926). We will never really know how many records Moore-Robinson might have collected but sold on to collectors.

Another aim of the Historical Section was to ensure that "suitable names" were applied to new areas and to preserve the accuracy of places "intimately associated" with the early settlement of Tasmania (RSA/H/3). In February 1922 the section pointed out to H.W. Gepp, manager of the Electrolytic Zinc Company, that the name Risdon, which had been used for his company's works, had been used by Bowen for the first settlement on the eastern side of the Derwent in 1803 (RSA/H/3). The section thought that, "from an historical point of view", the name Risdon should remain "definitely associated with this historical locality". While sympathising with efforts to prevent "the mutilation or destruction of the historical significance of Tasmanian names", Gepp would not change because his company and its products had been for some years associated with the name Risdon and any change would confuse his customers and involve "monetary loss". In 1925, Moore-Robinson also protested at the Council's inclination to rename St David's Park as Wilmot Park and made the case for keeping the name St David's (*The Mercury*, 4 May 1925). This time history triumphed and St David's was retained (*The Mercury*, 12 May 1925).

The final area we should consider is the holding of lectures and publishing of papers. While not a definitive list, we can identify lectures in 1921 on an 1839 voyage to England by William Crowther's grandfather (RSA/H/1); in 1922 on Macquarie's visits, Grime's survey of King Island, Knopwood's journal, early Hobart regattas, the currency used before 1825 and aspects of George Arthur's governorship (RSA/H/1); in 1923 on early industry and the Lady Franklin Museum (RSA/H/1); in 1925 on John Franklin's governorship (*The Mercury*, 25 December 1925); in 1926 on William Denison's governorship (RSA/H/1); and in 1927 on David Collins' governorship (PPRST 1927). Some of these lectures formed the basis of papers that were published in the *Papers and Proceedings of the Royal Society* (Somerville 1943; PPRST 1922–27 passim).

In 1927 the Historical Section became embroiled in a controversy when an article in *The Tasmanian Mail* criticised lectures on Collins' period as Governor (*The Tasmanian Mail*, 10 August 1927). According to the *Mail*, in the past "some of the scientific papers" read at Hobart meetings had "gained prominence in the highest quarters of the scientific world", but fewer people had an interest in science now and the Royal Society was in decline as a result. Symptomatic of decline were the lectures on Collins, which were given by "junior" members. Although some papers were "interesting in a way", they revealed nothing "new" and some were "not above the standard of essays done in the 5th and 6th forms of secondary schools".

The article was hurtful but hardly devastating, yet the section took the attack to heart because it implied that the society was "decadent", which in this context meant decaying or dying (RSA/H/2). As Reynolds explained to the Secretary of the Royal Society, the article would prevent some members from speaking in the future and weaken interest in Tasmanian history. The lecturettes were not papers prepared for publication as the society's scientific papers were, but "short talks giving sidelights" of Tasmanian history. Clive Lord was also incensed. He pointed out that in ten years the Society's membership had increased from 88 to 250 and in the same period the scientific papers were the equal of any published in the past (RSA/H/2). He disparaged the tendency to belittle "all that is Tasmanian". The Royal Society Council declined to respond to the article. After the criticisms, the Historical Section in Hobart seems to have fallen into abeyance. Individual members continued to give papers on historical subjects, but not as members of the section.

Despite its unprecedented efforts, some members thought the discussion of Tasmanian history should not be confined to the Historical Section of the Royal Society. The section's

scope was "limited" because its members were very busy men (PPRST 1925: 246). In July 1926 William Crowther suggested forming a Tasmanian historical society, but other members thought that "the time was not ripe for the inauguration of such a movement" (RSA/H/1, 8 July 1926). This in part reflected an elitist view and in part a belief that Tasmanians were still not ready to confront their past.

Launceston

In April 1921, Moore-Robinson visited Launceston looking for old records and found a "magnificent field" for historical research (*The Examiner* 28 April 1921). As evidence of a strong historical tradition in the north, he referred to some of Launceston's past eminent historians — John West, Ronald Gunn, Charles W. Rocher and Ernest Whitfeld — and suggested either that interested persons form an historical society as existed in Melbourne and other centres or that an historical section form part of a northern branch of the Royal Society, which had existed in the early 1860s. On 18 May a meeting decided to reform a northern branch of the Royal Society, but history did not loom very large in the branch's activities (*The Examiner*, 19 May 1921; RSNB Minute Book).

In 1926 Moore-Robinson was again the catalyst for public discussion on historical research. In June he spoke to the northern branch of the Royal Society on Governor Lachlan Macquarie's visits to Van Diemen's Land in 1811 and 1821, with special reference to Launceston (*The Examiner*, 22 June 1926). He urged members "to do some little thing to place on record some essential fact of which he or she has knowledge". As areas of research he suggested ships and shipping on the Tamar, banks and the names of places. In supporting Moore-Robinson, lawyer J.E. Heritage thought schoolchildren "should be educated to a better appreciation of Tasmanian history", whereby they would "learn something they had not got at present — that was love of their country". A small committee was set up to consider ways of finding out what old records existed in Launceston. At a later meeting to consider forming an association for historical research, Moore-Robinson raised the idea of forming a Tasmanian Historical Society because members of the Royal Society outside Hobart felt aggrieved that their "local subscriptions were not available for local requirements" and that, "generally speaking, interest centred in the society's premises in Hobart" (*The Examiner*, 9 July 1926). Moreover, the Royal Society was mainly a scientific body, but many people were more interested in historical research and wanted to meet like-minded others. The meeting decided to talk with members of the Royal Society before taking any action.

At that meeting on 23 July all agreed that two competing societies could not survive in Launceston and that it would be better if the Royal Society more actively encouraged historical interests and assisted in the collection of old records (*The Examiner*, 24 July 1926; RSNB Minute Book). A journal to disseminate historical articles was considered but rejected. Thereafter lectures on historical topics featured more regularly at meetings of the northern branch. These included, in 1927, educationist, historian and anthropologist A.L. Meston on "The Growth of a Constitution in Tasmania" and an informal meeting on recollections of early Launceston, where "personal reminiscences" of people, buildings and social conditions of the early 1860s were related (*The Examiner*, 23 June 1927 and 13 June 1928). An interest in history was further stimulated when, much to the chagrin of Hobart enthusiasts, the Queen Victoria Museum acquired, in late 1927, John Watt Beattie's collection on the early history of Tasmania (*The Examiner*, 13 June 1928; Young 1996).

CONCLUSION

It has been fashionable in some circles to claim that Tasmanians have lacked interest in their history. For example, in the 1980s Kay Daniels (1983: 3) thought that Tasmania was a "society which is still uncomfortable with its past, which sees its history as in some ways marked by a shameful inheritance" and Peter Conrad (1988: 96) once suggested that Tasmania had "unwritten its own history" to conform with "a self-protective incuriosity about origins". These comments are true to a point if we see Tasmanian history through the eyes of the Aborigines and the convict system and if we ignore other aspects of our history.

This paper has shown that the members of the Historical Section of the Royal Society were curious about Tasmanian history long before the 1980s. Some members studied the dark side, but only to whitewash the past by stressing the benefits of the convict system. Most members embraced other, more positive aspects of the past. They emphasised the bravery and intelligence of the early explorers, the development of constitutional forms and how successive governors overcame difficulties to create a viable society from unpromising beginnings. Mostly, they took an uncritical approach to their subjects and were celebratory, nostalgic and preservationist. As befitting men of their class, position and respectability in society, they were interested in celebrating but not challenging the status quo. They showed no interest in giving voices to the subaltern classes and the achievements of women hardly rated a mention unless they were married to a governor. Tasmanian history was a story of progress and the triumph of man's will and there was no need to acknowledge, let alone apologise, for the sins of the past.

Mostly, as determined by the lecture format, the research of section members was superficial. No member of the section attempted a penetrating monograph to explore diverse themes of Tasmanian history. They lacked either the training or the inclination, or both, to emulate the impressive general histories written by Henry Melville (1835), John West (1852) or James Fenton (1884). They were more comfortable in focusing on the facts and small, self-contained topics, which were accessible to their small number of conservative colleagues. But too much could not be expected of these pioneers of our local history. In small, tentative ways members of the historical section contributed to an understanding of Tasmania's past, helped to create a public awareness of early Tasmanian achievements, and did something to further the Royal Society's aim to advance knowledge. The approach might have been antiquarian, but in reminding Tasmanians that they had a history worth remembering and by collecting historical documents their work had value nonetheless.

REFERENCES

ASHTON, P. & HAMILTON, P., 2000: Blood money? Race and nation in Australian public history. *Radical History Review* 76: 188–207.

ANON., 1974: Alfred Mault (1829-1902). *Australian Dictionary of Biography.* Melbourne University Press, Melbourne 5: 229–30.

BISKUP, P., 1989: J. Moore-Robinson, a trader in records, in *Papers and Proceedings of the 7th biennial conference of the Australian Society of Archivists, Inc, Hobart 2–6 June 1989*: 46–56.

BOURKE, H., 1983: Herbert Heaton (1890–1973), *Australian Dictionary of Biography,* Melbourne University Press, Melbourne 9: 250–251.

CONRAD, P., 1988: *Down Home: Revisiting Tasmania.* Chatto & Windus, London.

Daily Telegraph newspaper (Launceston), references as cited in the text.

DANIELS, K., 1983: Cults of nature, cults of history. *Island Magazine* 16: 3–6.

DAVISON, G., 1988: The use and abuse of Australian history. *Australian Historical Studies* 23: 55–76.

DAVISON, G., 2000: *The use and abuse of Australian history.* Allen & Unwin, St Leonards.

ELIAS, A., 1981: Edward Albert Counsel (1849–1939). *Australian Dictionary of Biography,* Melbourne University Press, Melbourne 8: 121–122.

ELIAS, A., 1988: Leonard Rodway (1853–1936). *Australian Dictionary of Biography.* Melbourne University Press, Melbourne 11: 436-437.

The Examiner newspaper (Launceston), references as cited in the text.

FENTON, J., 1884: *A history of Tasmania from its discovery in 1642 to the present time.* Walch & Sons, Hobart.

FLETCHER, B.H., 1993: *Australian history in New South Wales 1888–1938.* University of New South Wales Press, Kensington.

GARDEN, D., 1998: Historical societies. *In* Davison, G., Hirst, J., & Macintyre, S. (Eds): *The Oxford companion to Australian history,* Oxford University Press, Melbourne: 318-319.

GRIFFITHS, T., 1996: *Hunters and collectors: The antiquarian imagination in Australia.* Cambridge University Press, Cambridge.

HALLIGAN, G.H., 1925: Tasman's landing place. *Papers and Proceedings of the Royal Society of Tasmania*: 195–202.

HEY, D. (ed), 1996: *The Oxford companion to local and family history.* Oxford University Press, Oxford.

HUXLEY, J., 2002: Curatorial zeal: the contribution of Alexander Morton to the Tasmanian Museum and Art Gallery 1884–1907. Unpublished B.A. (Hons) thesis, University of Tasmania.

LEVINE, P., 1986: *The amateur and the professional: antiquarians, historians and archaeologists in Victorian England, 1838–1886.* Cambridge University Press, Cambridge.

LORD, C., 1926: On the planting of the Dutch flag in Tasmania in 1642. *Papers and Proceedings of the Royal Society of Tasmania 1926*: 25–34.

MACINTYRE, S., 1992: History, a school for statecraft; or How shall we sing the Lord's song in a strange land? *Tasmanian Historical Research Association Papers and Proceedings* 39 (3): 105–117.

MADIGAN, C. T., 1936: Centenary Address: The past, present and future of the Society and its relation to the welfare and progress of the State. *Transactions of the Royal Society of South Australia* 60: i–xv.

MAIDEN, J.H., 1918: A contribution to a history of the Royal Society of New South Wales (with information in regard to other New South Wales societies). *Journal and Proceedings of the Royal Society of New South Wales* 52: 215–361.

MCC16/129/22, Minutes of the meetings of the Hobart City Council, Archives Office of Tasmania.

MELVILLE, H. S., 1835: *History of the island of Van Diemen's Land, from the year 1824 to 1835: inclusive, to which is added a few words on prison discipline.* Smith & Elder, London.

The Mercury newspaper, references as cited in the text.

MOORE-ROBINSON, J., 1921: Tasmanian State records. *Papers and Proceedings of the Royal Society of Tasmania 1921*: 156–65.

PEARSON, J., 1943: Centenary of the Royal Society of Tasmania. *Papers and Proceedings of the Royal Society of Tasmania 1943*: 223–231.

PPRST, 1898-1899: Minutes of annual meeting, 27 March 1899. *Papers and Proceedings of the Royal Society of Tasmania 1898-1899*: xxiii–vi.

PPRST, 1924: Annual report for 1924. *Papers and Proceedings of the Royal Society of Tasmania 1924*: 154–156.

PPRST, 1925: Historical and Geographical section report 1925. *Papers and Proceedings of the Royal Society of Tasmania 1925:* 244–246.

PPRST, 1926: Annual report for 1926. *Papers and Proceedings of the Royal Society of Tasmania 1926*: 184–186.

PPRST, 1927: Annual report of the Historical Section 1927. *Papers and Proceedings of the Royal Society of Tasmania 1927*: 232.

PUGH, R.B., 1970: *The Victoria history of the counties of England.* Oxford University Press, London.

REYNOLDS, J., 1966: Some recollections of the Tasman memorial controversy. *Tasmanian Historical Research Association Papers and Proceedings* 13 (2): 39–49.

ROE, M., 1977: *William Jethro Brown: an Australian Progressive, 1868–1930.* University of Tasmania, Hobart.

ROE, M., 1979: John Watt Beattie (1859-1930). *Australian Dictionary of Biography.* Melbourne University Press, Melbourne 7: 232–233.

ROE, M., 1989: Vandiemenism debated: the filming of "His natural Life" 1926/7. *Journal of Australian Studies* 24: 35–51.

ROE, M., 2001: *The state of Tasmania: identity at Federation time.* Tasmanian Historical Research Association, Hobart.

RSA/H/1: Minute book of the Historical and Geographical Section 19 May 1899–20 September 1900, 2 September 1921–20 July 1927, Royal Society of Tasmania papers, University of Tasmania Archives.

RSA/H/2: Papers of the Historical and Geographical Section 1899–1927, Royal Society of Tasmania papers, University of Tasmania Archives.

RSA/H/3: Letterbook of the Historical and Geographical Section 1899–1927, Royal Society of Tasmania papers, University of Tasmania Archives.

RSA/H/5: Scrapbook of the Historical and Geographical Section 1899–1904, Royal Society of Tasmania papers, University of Tasmania Archives.

RSNB Minute Book, Royal Society of Tasmania Northern Branch, State Library of Tasmania Launceston.

RYAN, L., 1981: *The Aboriginal Tasmanians.* University of Queensland Press, St Lucia.

SMITH, N., 1976: Thomas Stephens (1830–1913). *Australian Dictionary of Biography.* Melbourne University Press, Melbourne 6: 196.

SOMERVILLE, J., 1943 The Royal Society of Tasmania 1843–1943. *Papers and Proceedings of the Royal Society of Tasmania 1943*: 199–221

The Tasmanian Mail newspaper, references as cited in the text.

Tasmanian News newspaper, references as cited in the text.

W9/C9/1: Notes and correspondence on the proposed Historical Society 1884, James Backhouse Walker papers, University of Tasmania Archives.

WALKER, J.B., 1973: *Early Tasmania: papers read before the Royal Society of Tasmania during the years 1888 to 1899.* Government Printer, Hobart.

WEST, J., 1852: *The history of Tasmania,* 2 vols. Henry Dowling, Launceston.

WETTENHALL, R.L., 1983: Robert Mackenzie Johnston(e) (1843–1918). *Australian Dictionary of Biography.* Melbourne University Press, Melbourne 9: 501–503.

The World newspaper, references as cited in the text

YOUNG, D., 1996: *Making crime pay: the evolution of convict tourism in Tasmania.* Tasmanian Historical Research Association, Hobart.

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ADDITIONS TO THE FRESHWATER FAUNA OF HEARD ISLAND

by H. J. G. Dartnall

(with two text-figures and one table)

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Freshwater collections from Heard Island yielded a fauna of protozoans, one species of platyhelminth, two species of tardigrades, at least four species of nematodes, 16 species of rotifer (including two new species and four new records for the island), one species of enchytraeid worm, and nine species of arthropod (four anomopodans, two copepods and three mites). No ostracods were found, nor was any evidence of insects with aquatic or semi-aquatic larvae.

Key Words: freshwater invertebrates, rotifers, subantarctic, Heard Island.

INTRODUCTION

Heard Island at 52°58'–53°12'S; 73°15'–73°51'E, in the southern Indian Ocean, is one of the most isolated and probably the least well-known of the subantarctic islands. It has no permanent bases and is only visited sporadically. This paper describes the freshwater invertebrates collected in October/November 2000, and during February 2001. The first collection included material from some of the more isolated parts of the island, whilst the second was confined to areas near Atlas Cove, and to the eastern end of the island round Scholes Lagoon (fig.1).

SITE DESCRIPTION

Heard Island is a volcanic island (surface area 385 km^2) situated south of the Antarctic convergence in the southern Indian Ocean. With more than 65% of the island covered in glaciers (Doug Thost, pers. comm.), bodies of freshwater are confined to the coastal lowlands. Global warming has led to the retreat of many of the Heard Island glaciers that only a few years ago terminated in the sea. This has resulted in the formation and enlargement of large proglacial lakes contained within the terminal and lateral moraines at the snout of these glaciers. Extensive breaching of the terminal moraine by the sea at Compton Lagoon, intermittent breaching at Winston Lagoon and minor breaching at Stephenson Lagoon has resulted in seawater incursions and loss of lake water. The locations of the major lacustrine features together with those freshwater lakes sampled on this expedition are shown in figure 1.

Manning Lagoon on the south coast is not fed by glaciers (unlike Winston, Stephenson and Brown lagoons) and is confined by a beach barrier and sand dunes. The surrounding vegetation, known as pool complex (Whinam 1989) consists of *Poa cookii* (J.D. Hook) J.D. Hook, which grows as a 0.3 m high tussock, and the cushion plant *Azorella selago* J.D. Hook. At the time of the first collection there was an ice crust on the water and the surrounding pool complex was snow-covered.

The small lake at Cape Gazert is on the outside of the ice-cored lateral moraine on the southern flank of the Vahsel Glacier. A cobble beach separates the lake from the sea, while inland and to the northeast there is an ice-cored moraine. At the time of sampling the lake was ice-covered, with a 4 m^2 patch of open water.

The North West Cornice site consisted of a pool (0.5 m deep) and a nearby fast-flowing stream just 1.5 m across and 0.15 m deep. The area, which is enriched by penguin guano, is rocky with a surrounding *Poa cookii* water meadow. Patches of green algae were seen on the bottom of the pool.

Red Island Lagoon is on the northern promontory of Laurens Peninsula. The water at the time of sampling was described as 'a pale green soup' and is an Elephant seal wallow.

Wharf Point Lagoon on the eastern shore of Atlas Cove is a coastal lagoon (30 m by 10 m) separated from the sea by a beach ridge. As with Manning Lagoon, there is no glacial input into this lake and it is surrounded by *Poa cookii* and *Azorella selago*. Numerous Fur seals and Elephant seals were present and they have caused a wallows site (Wharf Point wallows) to be formed adjacent to, and to the east of, this lagoon.

The small lake on the western side of Azorella Peninsula was visited once, when it was still frozen over, and the surrounding vegetation was partially snow covered. A tiny patch of open water allowed the net to be inserted. The same conditions affected the small pond at Saddle Point.

The Dovers Moraine pools are a series of tarns among the moraines that run parallel to the Dovers Moraine. Up to 1.2 km from the coast, and some 50 m above sea level, they are small (the largest was some 50 by 25 m) and shallow. The surrounding vegetation ranged from barren soils with occasional *Pringlea antiscorbutica* R.Br. ex J.D. Hook, *Colobanthus kerguelensis* J.D. Hook, *Poa kerguelensis* (J.D. Hook) Strudel and *Bryum* spp. mosses to closed communities of *Azorella selago* and *Acaena magellanica* (Lam.) Vahl.

Scholes Lagoon is a very shallow, possibly ephemeral, lagoon at the western end of Spit Point.

Winston Lagoon is a proglacial lake with a glacial beach barrier that is frequently breached by the sea but was intact when sampled. During a botanical survey of the small island in this lagoon, a wet patch was sampled for freshwater invertebrates.

MATERIALS AND METHODS

Samples were obtained with cone-shaped plankton nets 50 cm long, 25 cm in diameter, and covered with a 35µm mesh. The net was cast into the water and slowly retrieved

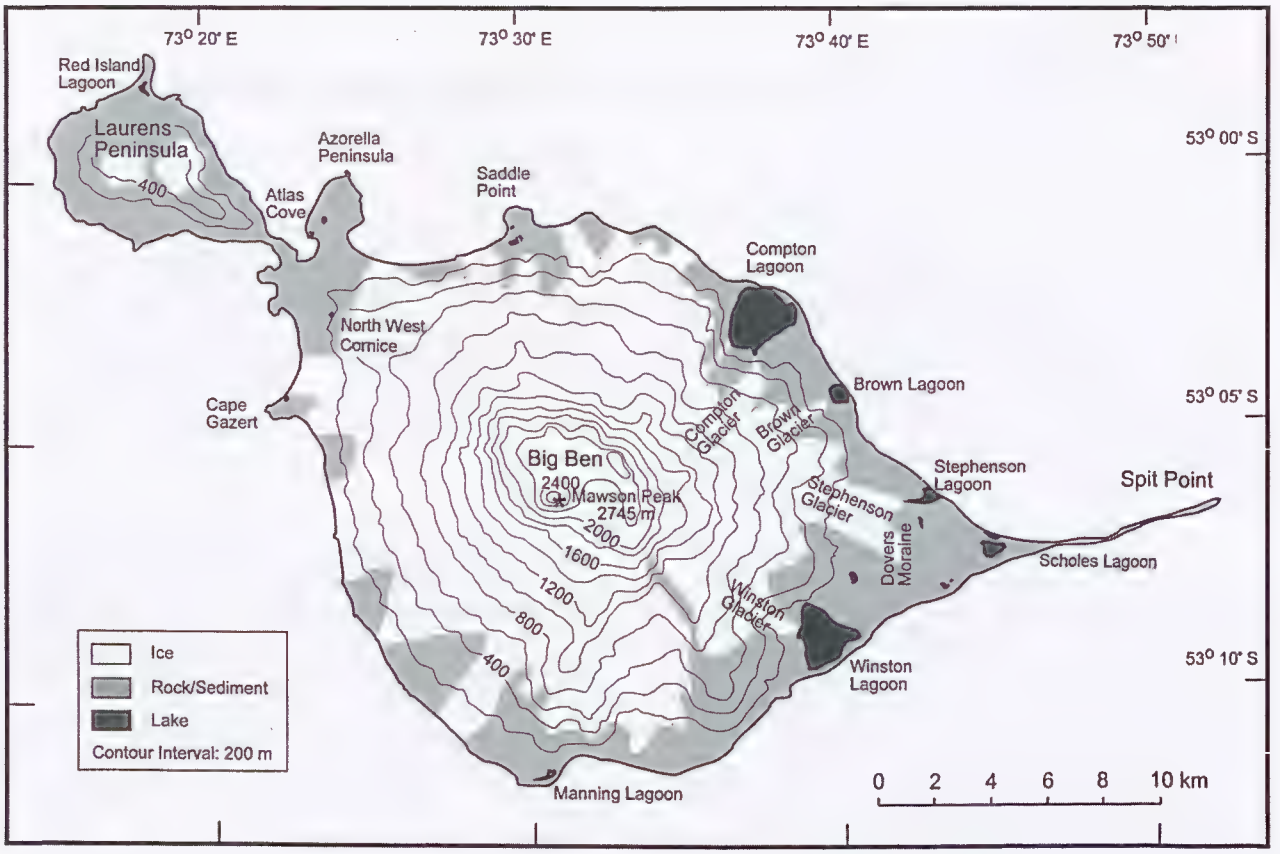

FIG. 1 — Map of Heard Island showing the locations of the sampling sites and other major freshwater bodies.

with the net opening on, or just above, the bottom so that it brushed through the benthic vegetation. The samples were stored in cool conditions (<4°C) until examination in Hobart using a dissecting microscope. Drawings were made from free-swimming specimens or from live specimens kept under slight compression by a coverslip mounted on Vaseline. Whole mounts, and slides of trophi were made using polyvinyl-lactophenol (PVL) after Russell's (1961) method.

RESULTS

The results of the 2000/2001 freshwater collections are given in table 1. Although the nets were not ideal for collecting Protozoa, small spherical and elongate, brown to colourless ciliates were noted at a number of locations, and a testate amoeba (*Arcella* sp.) was recovered from the small lake on the Azorella Peninsula. A solitary gastrotrich covered in sensory bristles (*Chaetonotus* sp.) was recovered from Manning Lagoon. Tardigrades were recovered from a number of sites. They were not identified but *Acutuncus* (=*Hypsibius*) *antarcticus* and *Dactylobiotus* sp. were recorded in an earlier survey (Dartnall 1995). Four species of nematode were regularly encountered. They were differentiated only by size, and probably represent more than four species. An additional nematode (5th sort) was recovered from wet ground on the island in Winston Lagoon but this is probably a terrestrial species.

Rotifers were represented by 16 species (11 Monogononta and five Bdelloidea). Of these, nine — *Encentrum heardensis, E. mustela, Epiphanes senta, Lepadella patella, L. triptera, Notholca hollowdayi, Trichocerca brachyura, Adineta* sp. and *Rotaria rotatoria* — have previously been reported from Heard Island (Dartnall 1995); four — *Cephalodella gibba, Encentrum uncinatum, Adinata vaga* and *Habrotrocha constricta* — are common species with a worldwide distribution including the subantarctic (Paggi S. 1982, Dartnall & Hollowday 1985, Dartnall, 1993, De Smet 2001). Two records — a *Notholca* and a *Dicranophorus* — are new species.

Notholca sp.
Fig. 2A, B

Two specimens of this species were found in the small tarns at the eastern end of the island (Dovers Moraine pools). They have the characteristic 'U'-shaped lorica adorned with six anterior spines typical of the genus *Notholca*. The anterior spines are needle-like and in one specimen the centre pair has a distinct bias (fig. 2B). The lorica is smooth or slightly striated, which is characteristic of the '*labis*' group. The posterior region of the dorsal lorica is extended some 70 µm in a spatulate fashion. Longitudinal indentations in this extension give the illusion of a foot segment with two short toes. At 285 µm this species is considerably bigger than *N. hollowdayi*, the commonest rotifer on Heard Island.

TABLE 1
The distribution of freshwater invertebrates found at Heard Island during the summer of 2000–01

	Manning Lagoon	Cape Gazert lake	North West Cornice stream	North West Cornice pool	Red Island Lagoon	Wharf Point wallows	Wharf Point lagoon	Azorella Peninsula lake	Saddle Point pond	Dovers Moraine tarns	Scholes Lagoon	Winston Lagoon	also known from
Protozoa													
ciliates	+		+		+	+				+	+		
Arcella sp.								+					
Plathyhelminthes													
Platyhelminth	+					+				+			
Gastrotricha													
Chaetonotus sp.	+												
Tardigrada													
Acutuncus antarcticus Richters and /or	+			+		+				+	+		SO, SS
Dactylobiotus sp.													
Nematoda													
Large nematode*	+		+	+		+				+			
Medium nematode*			+	+		+	+			+			
Monhystera sp.	+			+		+	+			+	+	+	
Tiny whip nematode*	+					+	+			+			
5th sort*												+	
Rotifera: Monogononta													
Cephalodella gibba (Ehrenberg)*	+		+				+			+			Mq, K, SG, SO, SS
Dicranophorus new species*	+												New Species
Encentrum heardensis Dartnall						+	+			+			
Encentrum mustela (Milne)	+						+						SG, SO, SS
Encentrum uncinatum (Milne)*							+						K, SO
Epiphanes senta O F Müller						+				+			Mq, SG, SO, SS
Lepadella patella (O F Müller)										+			Mq, K, SG, SS
Lepadella triptera Ehrenberg										+			Mq, SO, SS
Notholca hollowdayi Dartnall	+	+	+	+	+	+	+	+	+				K
Notholca new species*										+			New species
Trichocerca brachura (Gosse)											+		Mq, SG, SO
Rotifera: Bdelloidea													
Adineta vaga Davis*										+			Mq
Adineta sp.	+	+				+	+	+					Mq, SG, SO, SS
Habrotrocha constricta Dujardin*													SG, SO
live bearing bdelloid 3/3	+	+			+		+	+				+	
unidentified bdelloid			+	+						+	+		
Annelida: Oligochaetae													
Allolobophora tenuis Eisen	+	+	+			+							Mq, K
Arthropoda: Anomopoda													
Alona weinecki Studer	+			+				+			+		Mq, K, SG, SO, SS
Pleuroxus wittsteini Studer	+			+	+								K
Macrothrix hursuiticornis Norman & Brady	+			+						+			Mq, K, SG, SO
Daphniopsis studeri Ruhe	+		+				+			+	+	+	K
Arthropoda: Copepoda													
Boeckella brevicaudata (Brady)	+	+	+				+	+	+	+	+	+	Mq, K
Epactophanes richardi antarcticus (Richters)	+				+	+				+			K
Arthropoda: Acarina													
mites	+		+	+	+	+		+	+	+			
Others													
dead springtail					+								
dead marine copepod		+											
remains larval diptera	+												

+ = present, * = new record for Heard Island; Mq = Macquarie Island: Evans 1970, Frey 1988, Dartnall 1993; K = Kerguelen: Lair & Koste 1984, Duchene 1989, De Smet 2001; SG = South Georgia: Dartnall & Heywood 1980, Dartnall unpublished; SO = South Orkney Is.: Heywood et al 1979, 1980; Dartnall & Hollowday, 1985; SS = South Shetland Is.: Paggi S. 1982, Kuczynski 1987, Paggi J. 1987, Janiec 1993.

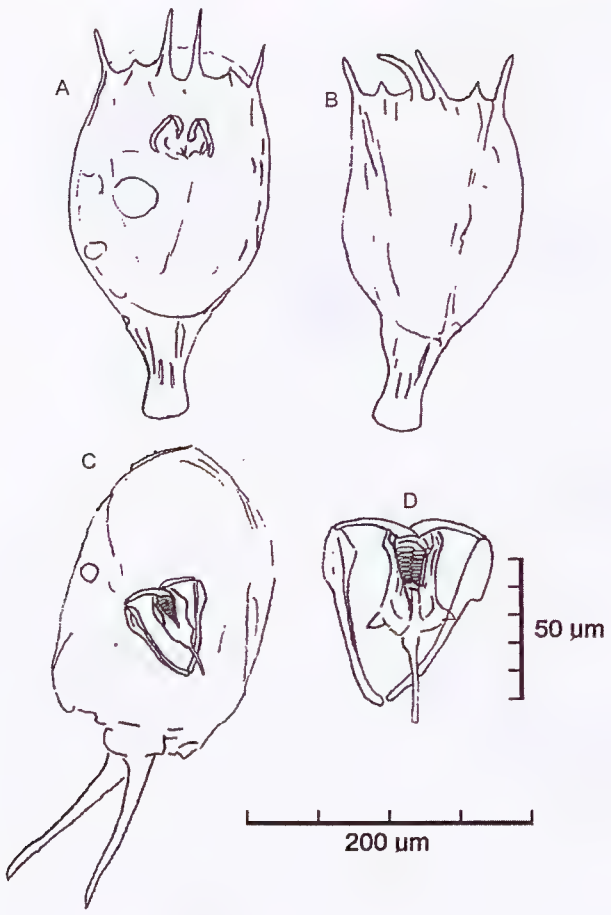

FIG. 2– (A, B) Notholca *sp. nov. (A) dorsal view of lorica; (B) ventral view of lorica. (C, D)* Dicranophorus *sp. nov.(C) lateral view of whole animal; (D) trophus.*

Dicranophorus sp.
Fig. 2C, D

This undescribed species was found in Manning Lagoon. Lightly loricated, with a pair of long toes (fig. 2C) it superficially resembles *Cephalodella gibba*, a species also present at Heard Island; however, the trophi are completely different. In the genus *Dicranophorus* the trophus is forcipate (cf. virgate for cephalodellids). The rami are broadly triangular at the base, curved anteriorly and terminating in two incurved teeth (fig. 2D). The median opening is large and lined with 9+ pairs of shearing teeth, decreasing in size towards the fulcrum. The alulae are triangular and conspicuous. The fulcrum is long and fractionally shorter than the ramus. The unci are strong and bear a single tooth. The manubria are long, gently curved, the anterior end clubbed and the posterior end smooth with a slight swelling (fig. 2D). The body is elongate and transparent. The foot is stout and short and bears two very long and strong toes. At 110 µm the toes are approaching one-third of the total length. The trophus, though some 50% larger at 60 µm, is similar to that of *Dicranophorus mesotis* Harring & Myres, a North American species. As with the undescribed *Notholca* noted above, more specimens are required before erecting a new species.

In addition to the freshwater invertebrates listed, a number of marine and terrestrial species was found. These interlopers include the torn remains of a marine copepod, which had presumably been dropped by feuding gulls and/or petrels, the ecdysed case of a larval dipteran, which had presumably been blown into Manning Lagoon and all of the springtails (ten species of Colembola are known from Heard Island – Dr S. Chown, pers. comm.). They are found on the water surface and amongst fringing vegetation and have not been included in this survey. They are considered to be terrestrial species.

DISCUSSION

The freshwater invertebrates found on this visit to Heard Island are listed in table 1. Notwithstanding the arthropods, which are predominately found in the larger bodies of water, the various habitats — lakes, pools, streams and wallows — have very similar faunas. No major seasonal differences could be detected between samples taken in spring (October/November) and those taken at the end of summer (February), so samples collected at different times from the same location have been combined.

The freshwater worm *Allolobophora tenuis* was recovered from a variety of habitats — lakes, wallows and streams and this is the 'large enchytraeid' previously reported from Heard Island (Dartnall 1995). All of the arthropods collected on this expedition have previously been found at Heard Island (Dartnall 1995). The two unidentified chydorid species of Dartnall (1995) are now known to be *Alona weineki* and *Pleuroxus wittsteini* (Werner Hollwedel, pers. comm.); and the identification of the calanoid copepod *Pseudoboeckella remotissima* Brehm is corrected to *Boeckella brevicaudata.* Several species of mite, including the aquatic species *Alophagus antarcticus* Hughes, were regularly encountered.

This survey failed to find ten species of rotifer reported in an earlier study (Dartnall 1995) — *Cephalodella sterae* (Gosse), *C. ventripes* Dixon-Nuttall, *Collotheca ornata cornuta* (Dobie), *Colurella colurus compressa* Lucks, *Euchlanis* sp., *Lindia torulosa* Dujardin, *Notommata glyphura* Wulfert, *Ptygura* sp., *Resticula gelida* (Harring & Myres) and *Rhinoglena frontalis* Ehrenberg; however, an additional six species of rotifer, including two new species, together with three species of nematode were recorded. This disappointingly small increase to the fauna is attributed to unavoidable sampling difficulties and logistic problems. During the spring, when the first collection was made, many of the lakes were still frozen and sampling was only possible either through melt holes, or close to the edge where the ice could be broken. Neither situation is ideal, as both inhibit the action of the plankton net. It was also very early in the season when the flora and fauna had not fully developed after the winter. Analysis of the second collection was delayed because of unavoidable changes to ships' itineraries causing deterioration of the material before examination. The earlier samples (Dartnall 1995) were collected in midsummer using similar equipment and collecting methods but were examined within five days. As a consequence a greater range and number of organisms, particularly the small species, survived until examination.

These records for Heard Island, though few, are sufficient to show remarkable similarities to the freshwater faunas of other subantarctic islands (table 1). No trace of ostracods or aquatic insects was found in the samples and there is increasing evidence to support this as a true record rather than a sampling anomaly.

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REFERENCES

DARTNALL, H.J.G., 1993: The rotifers of Macquarie Island. *ANARE Research Notes* 89: 41 pp.

DARTNALL, H.J.G., 1995: The rotifers of Heard Island: preliminary survey, with notes on other freshwater groups. *Papers and Proceedings of the Royal Society of Tasmania* 129: 7–15.

DARTNALL, H.J.G. & HEYWOOD, R.B., 1980: The freshwater fauna of South Georgia. *British Antarctic Survey Bulletin* 50: 115–118.

DARTNALL, H.J.G. & HOLLOWDAY E.D., 1985: Antarctic Rotifers. *British Antarctic Survey Scientific Reports* 100: 46 pp.

DE SMET, W.H., 2001: Freshwater Rotifera from plankton of the Kerguelen Islands (Subantarctica). *Hydrobiologia* 446/447: 262–272.

DUCHENE, J.C., 1989: *Kerguelen; recherches au bout du monde.* Laboratoire Arago 66650 Banyuls sur Mer, France: 360 pp.

EVANS, A.J., 1970: Some aspects of the ecology of a calanoid copepod, *Pseudoboeckella brevicaudata* Brady, 1875, on a subantarctic island. *ANARE Scientific Reports* 110: 100 pp.

FREY, D.G., 1993: Species of *Pleuroxus* (Anomopoda, Chydoridae) from the subantarctic islands and southernmost South America: a partial unravelling of the *Pleuroxus aduncus* problem. *Hydrobiologia* 262: 146–188.

HEYWOOD, R.B., DARTNALL, H.J.G. & PRIDDLE, J., 1979: The freshwater lakes of Signy Island, South Orkney Islands, Antarctica. *British Antarctic Survey Data* 3: 46 pp.

JANIEC, K., 1993: The Freshwater micro- and meifauna of Admiralty Bay, King George Island, South Shetland Islands. Proceedings NIPR Symposium. *Polar Biology* 6: 133–138.

KUCZYNSKI, D., 1987: Rotiferos del Genero *Branchionus* nuevos para la Antartida. *Instituto Antarctico Argentino* 360: 1–11.

LAIR, N. & KOSTE, W., 1984: The rotifer fauna and population dynamics of Lake Studer 2 (Kerguelen Archipelago) with description of *Filinia terminalis kergueleniensis* n. ssp. and a new record of *Keratella sancta* Russel, [sic] 1944. *Hydrobiologia* 108: 57–64.

PAGGI, J.C.DE, 1987: Estudios limnológicos en la isla Decepción, Shetland del Sur, Antárdida: aspectos taxonónomicos de los crustaceos dèl zooplankton. *Instituto Antárctico Argentino* 339: 1–34.

PAGGI, J.B.G., DE, 1982: *Notholca walterkostei* sp. nov. y ostros Rotiferos dulceacuicolas de la Peninsula Potter. Isla 25 de Mayo (Shetland del Sur, Antartida). *Revista Asociacion de Ciencias Naturales del Litoral* 13: 81–95.

RUSSELL, C.R., 1961: A simple method of permanently mounting Rotifera trophi. *Journal of the Quekett Microscopical Club, Series 5,* 5: 384–386.

WHINAM, J., 1989: Structure and floristic composition of the Heard Island "pool complex" community. *Polar Biology* 9: 499–503.

(accepted 24 November 2003)

GROWTH AND PHOTOSYNTHETIC RESPONSES TO ELEVATED [CO_2] IN GRASSES FROM TASMANIAN NATIVE PASTURE

by Mark J. Hovenden

(with five tables and two text-figures)

HOVENDEN, M.J., 2003 (19:xii): Growth and photosynthetic responses to elevated [CO_2] in grasses from Tasmanian native pasture. *Papers and Proceedings of the Royal Society of Tasmania* 137: 81–86. ISSN 0080-4703. School of Plant Science, University of Tasmania, Locked Bag 55, Hobart, Tasmania 7001, Australia.

Six species of grass (four C_3 and two C_4) from southeastern Australian native pastures were grown in controlled environment cabinets at current (~370 µmol CO_2 mol^{-1}) and twice current (~750 µmol CO_2 mol^{-1}) cabinet [CO_2]. Photosynthetic gas exchange and above-ground biomass were estimated after seven weeks. Cabinet [CO_2] had a highly significant impact on above-ground biomass (P<0.0003) with plants exposed to elevated [CO_2] having on average 78% greater above-ground biomass than the controls. The relative increase of above-ground biomass caused by elevated [CO_2] varied among species. [CO_2] during gas exchange measurements and species had highly significant impacts on carbon assimilation and evapotranspiration rates, stomatal conductance and water-use efficiency. Cabinet [CO_2] had a significant impact on carbon assimilation rate only, for which there was a significant cabinet [CO_2] × species interaction. Carbon assimilation rate was influenced by cabinet [CO_2] only for *Poa labillardierei*, but this may well be related to pot conditions. Three-factor analysis of variance found no interaction between cabinet [CO_2] and [CO_2] during photosynthetic measurements, further supporting a lack of photosynthetic acclimation to elevated [CO_2] in young plants of these temperate Australian grass species.
Key words: Climate change, elevated CO_2, grass, growth, photosynthesis, downregulation.

INTRODUCTION

Native grasslands are one of the most endangered plant communities of southeastern Australia and of Tasmania in particular (Kirkpatrick 1999). Much of the native grassy vegetation in southeastern Australia has been extensively modified through clearing, burning and grazing. As a result, there is little grassy vegetation that now remains in a 'natural' or semi-natural state, with about 90% of grassy woodlands being substantially altered or degraded (Kirkpatrick 1991). The alteration of grassy vegetation is particularly pronounced in southeastern Tasmania, where lowland *Poa labillardierei* Steudel-*Themeda triandra* Forsskal grasslands are described as the most threatened plant community in the state (Kirkpatrick 1999). Much of Tasmania's grassy vegetation is subject to grazing by livestock and is termed 'native pasture', but until recently it has been poorly studied from a management point of view (Garden *et al.* 1995, Mason & Kay 2000). This is despite the fact that native pasture provides grazing for over half of Tasmania's sheep flock. In addition, native pastures are highly significant from a conservation perspective both in their own right and because of the rare and endangered plant species they contain (Gilfedder 1990). There is also much to be gained in terms of improved soil chemistry and stability, improved water-use and a reduction of weeds from effective sustainable management of temperate Australian pastures (Kemp *et al.* 2000).

There is substantial evidence that global climate change, through elevated atmospheric temperature and [CO_2], will alter growth patterns in grassland species (Wand *et al.* 1999a). There is evidence that co-occurring pasture species vary in their response to climate change (Clark *et al.* 1999), which may lead to altered community interactions. Several studies have shown that species composition of grasslands does actually change in response to simulated conditions of climate change (e.g., Owensby *et al.* 1999). There is some information on the responses of tropical Australian grassland species to the changing climate (e.g., Howden *et al.* 1999), but no information concerning the potential impacts on Australian temperate pastures, despite their enormous financial and conservation significance.

Australian southern temperate grasslands differ substantially from more northern Australian grasslands in the relative abundance of C_3 and C_4 species (Hattersley 1983). Despite the large degree of interspecific variation within a functional type, there is evidence that C_3 species are more responsive to a doubling of [CO_2] than are C_4 species (Wand *et al.* 1999a). Tasmanian grasslands are particularly interesting from this point of view, in that they contain among the lowest abundance of C_4 species anywhere in the country (Hattersley 1983). Of the seven native Tasmanian C_4 grasses, only *Themeda triandra* is widespread and relatively abundant. Therefore, if elevated [CO_2] does impact on the growth and abundance of C_3 species, then Tasmanian pastures may be among the most affected.

This paper presents a first attempt at assessing responsiveness of biomass and photosynthetic gas exchange to elevated [CO_2] of several dominant grass species of southeastern Australian native pasture.

MATERIALS AND METHODS

Plant Material

Species studied are all native or naturalised in Tasmania according to Buchanan (1999). Four C_3 grasses were studied, namely *Austrodanthonia caespitosa* (Gaudich.) H. P. Linder, *Austrostipa pubinodis* (Trin. & Rupr.) S. W. L. Jacobs & J. Everett, *Dichelachne crinita* (L.f.) Hook.f. and *Poa labillardierei* Steudel, all of which are native to Tasmania. The C_4 grasses used were *Themeda triandra* Forsskal, the only widespread and successful Tasmanian native C_4 grass, and *Sporobolus africanus* (Poir.) Robyns & Tournay, which is native to Africa and is naturalised in Tasmania. All species are caespitose or tufted perennials. *Austrodanthonia* spp., *Poa*

spp. and *Themeda triandra* are perhaps the most important native pasture species, all being dominant under different conditions. *Austrostipa* spp. are widespread and can form a major component of grasslands, while *Dichelachne* spp. are occasionally important components. *Sporobolus africanus*, which was included because of the lack of C_4 species in Tasmanian native pasture, is an introduced species occasionally found in coastal grasslands and grassy woodlands. It has a very high growth rate under current conditions and produces seed prolifically and is therefore potentially highly invasive.

Seeds were collected from local wild populations of all species except *Sporobolus africanus*, seeds of which were collected from approximately 20 individuals growing in pots in the glasshouses of the School of Plant Science, University of Tasmania. These plants had been collected approximately six months earlier from a local area where the species is naturalised. Seeds were germinated in a 1:1:1 mix of sand, vermiculite and coconut fibre on a heat bed within a glasshouse at the University of Tasmania. When seedlings were approximately 1 cm high, 10 individuals of each species were planted out into 20 cm diameter pots (pot volume 4 L) containing a mixture of equal quantities of sharp sand and pine bark, to which slow-release fertiliser was added (Osmocote, Scotts-Sierra Horticultural Products, USA).

Five plants of each species were then transferred to each of two controlled environment cabinets (Thermoline, Smithfield, NSW, Australia) with a 14/10 h 25/12°C day/night cycle with daytime illumination of approximately 900 µmol $m^{-2}s^{-1}$ at plant height. The temperature chosen was about 2°C warmer than the average summer maximum temperature in the Midlands area of Tasmania. Cabinet relative humidity remained at approximately 50% throughout the experiment. One cabinet was maintained at a CO_2 concentration of approximately 750 µmol mol^{-1} by injection of pure CO_2 from a cylinder (BOC Gases). CO_2 control was provided by a microprocessor-controlled proportional integrating device (Thermoline, Smithfield, NSW, Australia). The $[CO_2]$ was measured constantly and varied by less than 20 µmol mol^{-1} from the set-point. The second cabinet was maintained at the current ambient CO_2 concentration of approximately 370 µmol mol^{-1}. The $[CO_2]$ of the controls was monitored routinely and varied by only ±10 µmol mol^{-1}. Plants were organised in a random block design within each cabinet and were watered daily, which was sufficient to keep the soil moist at all times.

After seven weeks, photosynthetic gas exchange was measured on each plant using a LI-COR LI-6400 portable photosynthesis system fitted with LI-6400-01 CO_2 gas mixer and LI-6400-04 blue-red LED light source (LI-COR, Ann Arbor, MI, USA). Gas exchange was measured in the middle part of the lamina of a young, well-expanded leaf. Several leaves were used at a time for *Poa labillardierei*, in which leaf width is typically <1 mm. *Austrostipa pubinodis* was not used for gas exchange measurements as it has tightly rolled leaves and proved difficult to measure. Leaf temperature was set at 25°C and the relative humidity in the chamber was kept at between 70–75% throughout all measurements. Leaf area was estimated by measuring the width of the leaf at either side of the chamber and multiplying the mean of the two leaf width measurements by the chamber width. Where more than one leaf was used, the sum of the areas of individual leaves was used. A test of this method using a flat-bed scanner and image analysis software indicated that the technique had an accuracy ±1 mm^2 with these linear leaves.

Gas exchange was measured at a leaf chamber $[CO_2]$ of 370 and 750 µmol mol^{-1} for each leaf, with photosynthetic photon flux density of 1000 µmol m^{-2} s^{-1}. The leaf was measured first at the $[CO_2]$ at which it was grown and then at the other concentration. Once the leaf was sealed into the chamber and again after changing the chamber $[CO_2]$, the leaf was allowed to equilibrate until readings stabilised, which typically took 15 to 30 min. Gas exchange calculations were according to von Caemmerer & Farquhar (1981).

After gas exchange measurements, the above-ground biomass of each plant was harvested by cutting the plant at soil level. Fresh weight was estimated, material was dried at 70°C for three days and then dry weight was estimated.

Results were analysed by two-way factorial analysis of variance, with $[CO_2]$ during growth and species the two factors examined, with the SAS statistical package (SAS Institute Inc. 2000) using general linear model procedures. Significant results were compared using the Ryan-Einot-Gabriel-Welsch *post hoc* comparison (Day & Quinn 1989).

RESULTS

Above-ground biomass was significantly influenced by $[CO_2]$ ($P<0.0003$) and was dependent upon species ($P<0.0002$) but there was no interaction between these terms. The average above-ground biomass of grasses grown at elevated $[CO_2]$ was 12.5±1.4 g while the mean value for the control plants was 7.0±1.0 g. Table 1 shows the above-ground biomass for each of the six species at elevated and current $[CO_2]$, as well as the average stimulation of above-ground biomass caused by elevated $[CO_2]$ for each species. At 370 µmol CO_2 mol^{-1}, *Sporobolus africanus* plants had the greatest above-ground biomass (table 1). Under elevated $[CO_2]$, *Poa labillardierei* was the largest, with *Austrostipa pubinodis*, *Austrodanthonia caespitosa* and *Sporobolus africanus* all reaching a similar size. *Dichelachne crinita* and *Themeda triandra* had the lowest above-ground biomass at elevated $[CO_2]$ (table 1).

Results for carbon assimilation rate are shown in figure 1 and all other gas exchange variables are shown in table 2. The results of the analysis of variance are presented in table 3. While it is obvious that both species and the CO_2 concentration during measurements, $[CO_2]_m$, had a highly significant impact on all gas exchange variables, cabinet CO_2 concentration, $[CO_2]_c$, only had a significant impact on net carbon assimilation. However, the significant species × $[CO_2]_c$ interaction ($P<0.01$) indicated that the impact of elevated $[CO_2]$ on carbon assimilation was dependent upon species. This is supported by figure 1, in which it is obvious that cabinet $[CO_2]$ significantly affected assimilation in *Poa labillardierei* only.

If photosynthetic acclimation occurred, then this would be evident in differences in the response to measurement $[CO_2]$ between plants exposed to elevated $[CO_2]_c$ and those exposed to current $[CO_2]_c$. Any impact of $[CO_2]_c$ on the photosynthetic response to $[CO_2]_m$ would be indicated by a significant $[CO_2]_c$ × $[CO_2]_m$ interaction in the analysis of variance. From table 3, it is evident that the $[CO_2]_m$ × $[CO_2]_c$ interactions were highly non-significant for all variables, as was the three-way interaction of species × $[CO_2]_m$ × $[CO_2]_c$.

The short-term responsiveness of gas exchange to $[CO_2]$, as examined by the ratio of measurements made at 750 µmol CO_2 mol^{-1} to those made at 370 µmol CO_2 mol^{-1} for each plant, also indicated no significant differences between

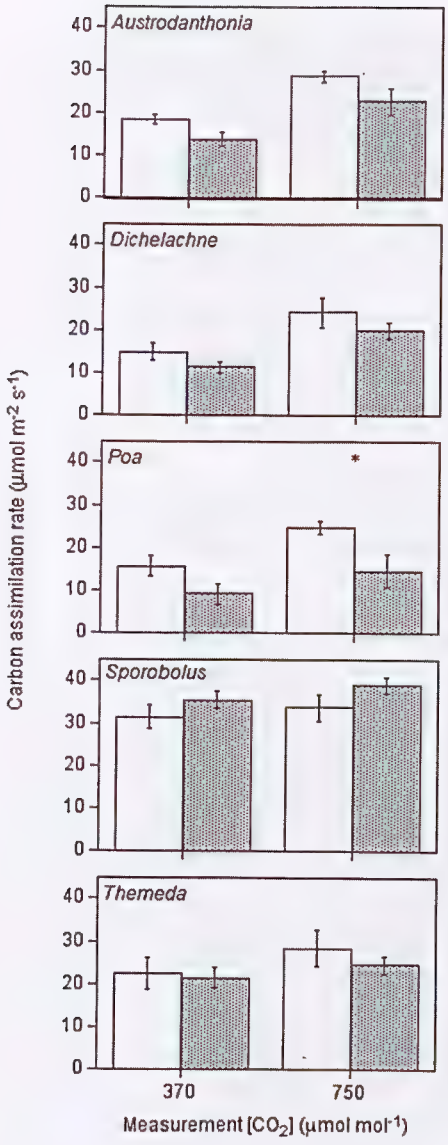

FIG. 1 — Carbon assimilation rates of grass species at 370 µmol mol^{-1} and 750 µmol mol^{-1} CO_2 concentration. Plants were grown at either current (open columns) or twice current (shaded columns) [CO_2]. Error bars indicate ±S.E., n=5.

plants grown at current $[CO_2]_c$ and those grown at elevated $[CO_2]_c$ (table 4). There was, however, a significant effect of species on short-term gas exchange responsiveness to $[CO_2]$ (table 4). This was due to the carbon assimilation rate of the C_4 species, *Themeda triandra* and *Sporobolus africanus*, being less responsive to $[CO_2]_m$ than that of the C_3 species. In contrast, elevated $[CO_2]_m$ caused a larger reduction in both stomatal conductance and evapotranspiration rate in C_4 species than it did in C_3 species.

Analysis of the photosynthetic characteristics at each plant's $[CO_2]_c$ (each plant's 'home' $[CO_2]$), shows that significant differences existed in the steady state gas exchange of plants growing at current compared to elevated $[CO_2]_c$ (table 5). The only measured gas exchange variable that did not vary between current and elevated $[CO_2]_c$ treatments was the ratio of intercellular to ambient $[CO_2]$, c_i/c_a, indicating a consistent stomatal response to $[CO_2]_m$ between the treatments (table 5). There was an impact of species on all gas exchange variables, but a significant species × CO_2 interaction only for instantaneous WUE (P<0.04) (fig. 2). Hence, the carbon assimilation rate of plants growing at current $[CO_2]_c$ was significantly less than that of plants growing at elevated $[CO_2]_c$ (table 5). Stomatal conductance, and hence evapotranspiration rate, was lower in plants growing at elevated $[CO_2]_c$. Together, these differences lend the plants growing at elevated $[CO_2]$ a significantly higher intrinsic WUE (fig. 2, table 5).

DISCUSSION

These results demonstrate that substantial differences in the potential growth response to elevated $[CO_2]$ occur among Tasmanian grasses. This variation is partly related to photosynthetic pathway, since *Sporobolus africanus*, the least responsive species, is C_4 while *Poa labillardierei* and *Austrostipa pubinodis*, the most responsive species, are C_3. Photosynthetic pathway is not, however, sufficient to explain the variation in the growth response to elevated $[CO_2]$, since *Themeda triandra* (C_4) responded similarly to *Dichelachne crinita* (C_3) (table 1). There is little evidence of photosynthetic acclimation to elevated $[CO_2]$, as indicated by highly non-significant $[CO_2]_c \times [CO_2]_m$ interactions.

Instantaneous photosynthetic rates were approximately 21% higher and evapotranspiration rates 17% lower in plants growing at elevated $[CO_2]$ than in those growing in current conditions (table 5). Furthermore, intrinsic

TABLE 1
Above-ground dry weight (g) of each species grown at current (370 µmol CO_2 mol^{-1}) or elevated (750 µmol CO_2 mol^{-1}) CO_2 concentrations

Species	C_3/C_4	Current CO_2	Elevated CO_2	Growth enhancement
Austrodanthonia caespitosa	C_3	6.3 ± 1.2	12.4 ± 1.8	95%
Austrostipa pubinodis	C_3	5.1 ± 1.9	13.8 ± 3.0	169%
Dichelachne crinita	C_3	4.0 ± 1.2	6.5 ± 1.5	65%
Poa labillardierei	C_3	6.5 ± 1.9	19.7 ± 4.6	201%
Sporobolus africanus	C_4	15.9 ± 3.0	15.5 ± 3.2	–2%
Themeda triandra	C_4	3.6 ± 1.0	6.8 ± 1.9	90%

Biomass values are means ± SE, n = 5. Growth enhancement is the percentage change in mean above-ground biomass for each species caused by elevated CO_2.

TABLE 2
Photosynthetic gas exchange variables measured at a $[CO_2]$ of 370 and 750 μmol mol^{-1} for five grass species grown at either current (370 μmol CO_2 mol^{-1}) or double (750 μmol CO_2 mol^{-1}) $[CO_2]$

Species	$[CO_2]$ Treatment	E (mmol H_2O m^{-2} s^{-1}) 370		750		g_s (mmol H_2O m^{-2} s^{-1}) 370		750		c_i/c_a 370		750		A/g_s (mmol CO_2 mol H_2O^{-1}) 370		750	
Austrodanthonia caespitosa	Current	2.39	±0.19	2.03	±0.22	277	±26	227	±30	0.627	±0.031	0.655	±0.027	69	±6.1	133	±13.3
	Double	3.13	±0.57	2.67	±0.54	266	±54	227	±54	0.684	±0.039	0.691	±0.044	59	±9.0	121	±22.0
Dichelachne crinita	Current	2.67	±0.18	2.61	±0.17	269	±23	257	±15	0.697	±0.022	0.750	±0.022	55	±4.0	93	±9.5
	Double	2.19	±0.47	2.17	±0.30	212	±28	207	±15	0.712	±0.013	0.746	±0.013	54	±3.3	97	±3.9
Poa labilliardierei	Current	2.44	±0.29	2.32	±0.32	263	±57	259	±62	0.668	±0.023	0.705	±0.047	64	±6.8	113	±22.4
	Double	1.68	±0.41	1.46	±0.38	170	±59	137	±49	0.694	±0.041	0.683	±0.068	61	±10.8	127	±29.6
Sporobolus africanus	Current	2.95	±0.29	2.05	±0.29	317	±37	211	±37	0.438	±0.015	0.538	±0.039	100	±4.7	173	±21.3
	Double	3.43	±0.39	2.73	±0.42	341	±33	250	±45	0.412	±0.024	0.529	±0.085	105	±5.8	183	±39.0
Themeda triandra	Current	2.50	±0.45	1.70	±0.12	188	±29	140	±19	0.409	±0.031	0.476	±0.050	118	±5.5	219	±47.7
	Double	2.17	±0.32	1.40	±0.21	174	±15	102	±10	0.390	±0.033	0.442	±0.036	123	±6.1	247	±22.9

Figures shown are means ± S.E., n=5. Abbreviations are defined in the text.

TABLE 3
Results of three-way ANOVA (P>F) for gas exchange variables for five cool temperate Australian grass species

Source of variation	A	E	g_s	c_i/c_a	A/g_s	A/E
Species	**0.0001**	**0.003**	**0.0001**	**0.0001**	**0.0001**	**0.0001**
$[CO_2]_c$	0.01	0.69	0.06	0.91	0.63	0.11
$[CO_2]_m$	**0.0001**	**0.007**	**0.008**	**0.006**	**0.0001**	**0.0001**
Species × $[CO_2]_c$	**0.01**	**0.01**	0.14	0.68	0.88	**0.04**
Species × $[CO_2]_m$	0.30	0.42	0.46	0.41	0.1	0.28
$[CO_2]_c$ × $[CO_2]_m$	0.54	0.97	0.91	0.61	0.59	0.58
Sp. × $[CO_2]_c$ × $[CO_2]_m$	0.97	0.99	0.99	0.99	0.99	0.96

$[CO_2]_c$ = cabinet $[CO_2]$ during growth, $[CO_2]_m$ = $[CO_2]$ during gas exchange measurements. Bold figures indicate significant results (P<0.05).

TABLE 4
Results of ANOVA (P>F) on short-term responsiveness to $[CO_2]$

	CO_2	Species	CO_2 × species
Net Assimilation Rate (A),	0.75	**0.0001**	0.38
Evapotranspiration rate (E)	0.97	**0.003**	0.58
Stomatal conductance (g_s)	0.34	**0.005**	0.31
c_i/c_a	0.54	**0.05**	0.98
Instantaneous water-use efficiency (A/E)	0.95	0.28	0.91
Intrinsic water-use efficiency (A/g_s)	0.41	0.57	0.98

Bold figures indicate significant results (P<0.05).

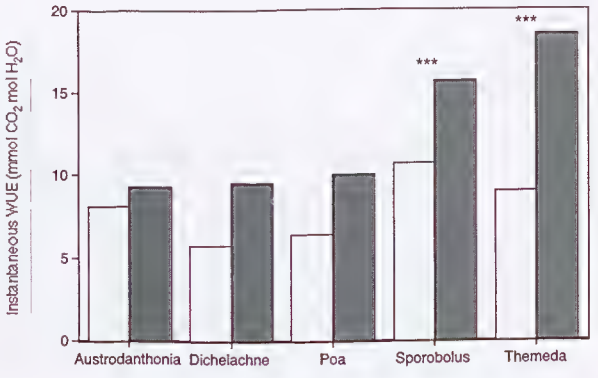

*FIG. 2 — Instantaneous water–use efficiency (A/E) measured at 370 μmol CO_2 mol^{-1} for plants grown in current $[CO_2]$ (open columns) and at 750 μmol CO_2 mol^{-1} CO_2 for plants grown at twice current $[CO_2]$ (shaded columns). *** indicates significant differences between means (P<0.001).*

TABLE 5
Mean photosynthetic gas exchange characteristics of plants grown at current or elevated [CO_2]

Variable	Current CO_2	Elevated CO_2
Net assimilation rate (A) (μmol m^{-2} s^{-1})	20.6[b]	25.0[a]
Evapotranspiration rate (E) (mmol m^{-2} s^{-1})	2.59[a]	2.14[b]
Stomatal conductance (g_s) (mmol m^{-2} s^{-1})	263[a]	189[b]
c_i/c_a	0.568[a]	0.612[a]
Intrinsic WUE (A/g_s) (mmol CO_2 mol H_2O^{-1})	81[b]	157[a]

Figures are the means for pooled data of all species. In each row, numbers with a different superscript are significantly different ($P<0.05$).

WUE (as estimated by A/g_s) of plants growing at elevated [CO_2] was approximately double that of plants growing in current conditions. These differences in carbon assimilation and transpiration would doubtless allow plants to grow significantly more quickly at elevated [CO_2] than they do in current conditions. Other than *Sporobolus africanus*, species used in this experiment were all caespitose and therefore the above-ground biomass was almost exclusively leaf material. Since the plants exposed to elevated [CO_2] had a greater above-ground biomass, they would also have had a greater leaf mass and hence the total carbon assimilation rate for the plant would have been greater than just the area-based measurements of CO_2 exchange. Further work should relate the relative growth rate of these species to instantaneous carbon assimilation and canopy leaf area. Only above-ground growth was estimated in this experiment, so it is entirely possible that root growth and whole-plant growth was different from the results shown here.

Photosynthetic downregulation, or acclimation, in response to elevated [CO_2] has been observed in many cases and mechanistic models developed to explain the results (e.g., van Oosten & Besford 1996). However, there is still no agreement that photosynthetic downregulation is a universal response to elevated [CO_2] (Sage 1994). The lack of photosynthetic acclimation to $[CO_2]_c$ in the C_4 species presented here agrees with the results for *Panicum coloratum* grown in pots for six weeks (Ghannoum 1998), as well as for *Paspalum dilatatum* grown in a pasture exposed to free-air CO_2 enrichment (von Caemmerer *et al.* 2001), in which there was little evidence for photosynthetic downregulation. The lack of significant photosynthetic downregulation in the C_3 species *Austrodanthonia caespitosa* and *Dichelachne crinita* disagrees with the results for *Panicum laxum* (Ghannoum 1998), *Lolium perenne* (von Caemmerer *et al.* 2001), as well as many other C_3 grass species reported to display photosynthetic downregulation. There is, however, contrasting evidence such as that for *Avena barbata*, in which no significant downregulation was observed in grasslands exposed to elevated [CO_2] (Jackson *et al.* 1995). Recent results from a free air CO_2 enrichment study showed a significant downregulation of photosynthesis in each of 13 grassland species, irrespective of photosynthetic pathway (Lee *et al.* 2001). The results presented here indicate a significant photosynthetic downregulation in response to elevated [CO_2] in *Poa labillardierei* only. It is possible, however, that the downregulation observed here is due to pot size or nutrient limitations, since the *P. labillardierei* plants grown at elevated [CO_2] were relatively large compared to the other plants in this study and 4 L pots were used (Sage 1994).

The length of this experiment (seven weeks) was short in comparison to some other experiments (e.g., Roumet *et al.* 2000), but significant photosynthetic acclimation to elevated [CO_2] has been noted for other grass species in less time (e.g., Ghannoum 1998). The results here indicate that during the establishment period when the plant is young, photosynthetic downregulation is not a significant factor in the response of these species to elevated [CO_2]. However, the photosynthetic characteristics of the species may have varied over time and with developmental stage.

The growth enhancement caused by elevated [CO_2] seen here is large compared with other studies. Wand *et al.* (1999a) showed through a meta-analysis that the average response of wild C_3 and C_4 grasses to elevated [CO_2] was an increase in whole plant dry weight of 44% and 33% respectively. The shoot growth response of *Themeda triandra* to elevated [CO_2] seen here is very similar to the results of Wand *et al.* (1999b) for the same species grown under similar conditions. The comparative maximum seen here was an increase of shoot dry mass of 190%. This could be because plants in this experiment were provided with ample nutrients, which allowed the full potential of growth increase to be realised. Also, the cabinets used in this experiment operated at a relative humidity of approximately 50%, giving a relatively large vapour pressure deficit. Since elevated [CO_2] has a direct effect on stomatal conductance, those plants in the elevated [CO_2] chamber may have had significantly higher shoot water potential than those in the control chamber and this could have directly affected their growth. Large vapour pressure deficits have been seen to increase the growth enhancement caused by elevated [CO_2] in other species (Seneweera 1998). The biomass of *Sporobolus africanus* was least affected by elevated [CO_2] (table 1). This supports previous work in which *Sporobolus cryptandrus* (Torr.) A. Gray was shown to have a slight reduction in biomass under elevated [CO_2] compared to controls (Kellogg *et al.* 1999).

The variation in responsiveness of above-ground biomass to elevated [CO_2] among the six species studied here has important implications for the future management and conservation of southeastern Australian grasslands. While competitive interactions in grasslands involve such processes as fecundity and stress tolerance among others, initial growth rate is very important in southeastern Australian grasslands, where rapid establishment in bare areas after the summer drought is an important facet of a species' success (Garden *et al.* 2000). The extremely high responsiveness of *Poa labillardierei*, which showed the potential for a tripling of above-ground growth with a doubling of [CO_2], and *Austrostipa pubinodis* have particularly important ramifications for the sustainable management of native pasture in Tasmania. Native pasture in Tasmania is largely dominated by *Austrodanthonia* spp. at altitudes below 600 m and by *Poa labillardiereil Poa rodwayi* above 600 m because of their tolerance of heavy grazing (Garden *et al.* 1995). *Themeda triandra* becomes dominant in drier areas where *Poa labillardierei* appears to be limited by low water availability (Kirkpatrick 1999). Doubling the [CO_2] causes an increase in the water-use efficiency of all grass species in this study,

since there is little evidence of stomatal acclimation to growth at elevated [CO_2]. This may allow *Poa labillardierei* to extend its current dominance into drier areas at the expense of the more drought tolerant *Themeda triandra.*

This study used only a few of the species from native grasslands, and plants were all grown singly, in relatively small pots, in controlled environment cabinets and given an adequate supply of water and nutrients. The performance of plants in natural soils and environmental conditions may well differ substantially from that reported here. However, the experiment was designed to investigate the effects of elevated [CO_2] on the growth potential of several species and to generate hypotheses to test under more realistic environmental conditions, and, as such, has been successful. This study shows that differences do occur in the CO_2-responsiveness of important dominant species in grasslands and native pasture of southeastern Australia, but that this responsiveness is not easily explained by short-term photosynthetic gas exchange measurements. This study provided little evidence that significant downregulation of photosynthesis occurs in young plants in response to elevated [CO_2]. Variation in the growth response of southeastern Australian grassland species to elevated [CO_2] is an area requiring further investigation, including detailed experiments into the competitive interactions of important pasture species and the investigation of botanical composition, productivity and palatability of pastures exposed to simulated future climates.

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REFERENCES

BUCHANAN, A. M., 1999: *A Census of the Vascular Plants of Tasmania.* Tasmanian Herbarium, Hobart.

CLARK, H., NEWTON, P. & BARKER, D., 1999: Physiological and morphological responses to elevated CO_2 and a soil moisture deficit of temperate pasture species growing in an established plant community. *Journal of Experimental Botany* 50: 233–242.

DAY, R. W. & QUINN, G. P., 1989: Comparisons of treatments after an analysis of variance in ecology. *Ecological Monographs* 59: 433–463.

GARDEN, D., JONES, C., FRIEND, D., MITCHELL, M. & FAIRBROTHER, P., 1995: Regional research on native grass-based pastures. *In* Reid, R. (Ed.): *Perennial Grasses 1995.* Land and Water Resources Research and Development Corporation: Launceston, Tasmania: 32–49

GARDEN, D. L., LODGE, G. M., FRIEND, D. A., DOWLING, P. M. & ORCHARD, B. A., 2000: Effects of grazing management on botanical composition of native grass based pastures in temperate south east Australia. *Australian Journal of Experimental Agriculture* 40: 225–245.

GHANNOUM, O., 1998: Nitrogen deficiency precludes a growth response to CO_2 enrichment in C_3 and C_4 *Panicum* grasses. *Australian Journal of Plant Physiology* 25: 627–636.

GILFEDDER, L., 1990: Threatened species from Tasmania's remnant grasslands. *Tasforests* 2: 129–132.

HATTERSLEY, P. W., 1983: The distribution of C_3 and C_4 grasses in Australia in relation to climate. *Oecologia* 57: 113–128.

HOWDEN, S., MCKEON, G., WALKER, L., CARTER, J., CONROY, J., HALL, W., ASH, A. & GHANNOUM, O., 1999: Global change impacts on native pasture in south-east Queensland, Australia. *Environmental Modelling and Software* 14: 307–316.

JACKSON, R. B., LUO, Y., CARDON, Z. G., SALA, O. E., FIELD, C. B. & MOONEY, H. A., 1995: Photosynthesis, growth and density for the dominant species in a CO_2-enriched grassland. *Journal of Biogeography* 22: 221–225.

KELLOGG, E., FARNSWORTH, E., RUSSO, E. & BAZZAZ, F., 1999: Growth responses of C_4 grasses of contrasting origin to elevated CO_2. *Annals of Botany* 84: 279–288.

KEMP, D., MICHALK, D. & VIRGONA, J., 2000: Towards more sustainable pastures: lessons learnt. *Australian Journal of Experimental Agriculture* 40: 343–356.

KIRKPATRICK, J., 1991: The magnitude and incidence of land clearing in Tasmania in the nineteen eighties. *Tasforests* 3: 11–14.

KIRKPATRICK, J., 1999: Grassy vegetation and subalpine eucalypt communities. *In* Reid, J., Hill, R., Brown, M. & Hovenden, M. (Eds): *Vegetation of Tasmania.* Australian Biological Resources Study, Canberra: 265–285.

LEE, T. D., TJOELKER, M. G., ELLSWORTH, D. S. & REICH, P. B., 2001: Leaf gas exchange responses of 13 prairie grassland species to elevated CO_2 and increased nitrogen supply. *New Phytologist* 150: 405–418.

MASON, W. & KAY, G., 2000: Temperate pasture sustainability key program: an overview. *Australian Journal of Experimental Agriculture* 40: 121–123.

OWENSBY, C., HAM, J., KNAPP, A. & AUEN, L., 1999: Biomass production and species composition change in a tallgrass prairie ecosystem after long-term exposure to elevated atmospheric CO_2. *Global Change Biology* 5: 497–506.

ROUMET, C., GARNIER, E., SUZOR, H., SALAGER, J. & ROY, J., 2000: Short and long-term responses of whole-plant gas exchange to elevated CO_2 in four herbaceous species. *Environmental and Experimental Botany* 43: 155–169.

SAGE, R., 1994: Acclimation of photosynthesis to increasing atmospheric CO_2: the gas exchange perspective. *Photosynthesis Research* 39: 351–368.

SAS INSTITUTE INC. 2000 *SAS/STAT user's guide, version 8.* SAS Publishing: Cary, NC.

SENEWEERA, S. P., GHANNOUM, O. & CONROY, J. 1998: High vapour pressure deficit and low soil water availability enhance shoot growth responses of a C_4 grass (*Panicum coloratum* cv. Bambatsi) to CO_2 enrichment. *Australian Journal of Plant Physiology* 25: 287–292.

VAN OOSTEN, J.-J. & BESFORD, R. T., 1996: Acclimation of photosynthesis to elevated CO_2 through feedback regulation of gene expression: climate of opinion. *Photosynthesis Research* 48: 353–365.

VON CAEMMERER, S. & FARQUHAR, G. D., 1981: Some relationships between the biochemistry of photosynthesis and the gas exchange of leaves *Planta* 153: 376–387.

VON CAEMMERER, S., GHANNOUM, O., CONROY, J. P., CLARK, H. & NEWTON, P. C. D., 2001: Photosynthetic responses of temperate species to free air CO_2 enrichment (FACE) in a grazed New Zealand pasture. *Australian Journal of Plant Physiology* 28: 439–450.

WAND, S., MIDGLEY, G., JONES, M. & CURTIS, P., 1999a: Responses of wild C_4 and C_3 grass (Poaceae) species to elevated atmospheric CO_2 concentration: a meta-analytic test of current theories and perceptions. *Global Change Biology* 5: 723–741.

WAND, S., MIDGLEY, G. & STOCK, W., 1999b: Predicted responses of C_4 grass-dominated southern African rangelands to rising atmospheric CO_2 concentrations. *In* Eldridge, D. & Freudenberger, D. (Eds): *People and Rangelands: Building the Future. VI International Rangelands Conference Inc,* Townsville, Australia: 922–923.

(accepted 24 November 2003)

STRATIGRAPHIC RESULTS OF DIAMOND DRILLING OF THE HUNTERSTON DOME, TASMANIA: IMPLICATIONS FOR PALAEOGEOGRAPHY AND HYDROCARBON POTENTIAL

by C. M. Reid, A. D. Chester, A. R. Stacey and C. F. Burrett

(with seven text-figures)

Reid, C.M., Chester, A.D., Stacey, A.R. & Burrett, C.F., 2003 (19:xii): Stratigraphic results of diamond drilling of the Hunterston Dome, Tasmania: implications for palaeogeography and hydrocarbon potential. *Papers and Proceedings of the Royal Society of Tasmania*, 137: 87–94. ISSN 0080-4703. School of Earth Sciences, University of Tasmania, GPO Box 252-79, Hobart, Tasmania 7001, Australia. (CMR*, ADC, ARS, CFB) * Author for correspondence.

The structure known as the Hunterston Dome, in central Tasmania, was drilled to a depth of 1324 m, through Jurassic dolerite, Lower Parmeener Supergroup and into Precambrian dolomite basement. The base of the Lower Parmeener Supergroup does not outcrop in the area, and drilling revealed the absence of the extensive glacial diamictites present elsewhere in the Tasmania Basin. A conglomeratic facies is found in place of the Bundella Mudstone and Woody Island Siltstone. Basement to the Lower Parmeener Supergroup is shown to be deformed Precambrian dolomite, of similar lithology to the relatively undeformed Black River Dolomite of northwestern Tasmania. Significant hydrocarbons were not encountered during drilling, but stratigraphic drilling proved the maturity of potential source beds in the region and the nature of potential reservoir rocks, where they are found in close association with a dolerite intrusion.

Key Words: Lower Parmeener Supergroup, Hunterston Dome, dolomite, hydrocarbons, palaeogeography, stratigraphy, dolerite.

INTRODUCTION

The geology of the Waddamanna region, central Tasmania, was first described by Fairbridge (1949), after regional mapping work for the Hydro-Electric Commission. Fairbridge described the Permian and Triassic rocks of the area and their structural relationship with Jurassic dolerite intrusives, and was the first to note the presence of a domal structure southeast of Lake Echo. This structure is named the Hunterston Dome, after the pastoral property covering the area. Fairbridge gave an accurate description of the local Permian geology and gentle dip of the strata. However, the 'sandy facies' of Fairbridge (1949), outcropping on the eastern and northeastern limb of the dome, is in fact the lower part of the freshwater Triassic.

The Hunterston area provides some of the only Permian (Lower Parmeener Supergroup) outcrop through the central Highlands region. However, only the marine series above the freshwater interval is exposed (fig. 1). The nature of the lower marine interval of the Lower Parmeener Supergroup is unknown, but extensive tillites and pyritic mudstones are known to the east (Forsyth 1989) and southwest (Jago 1971). To the northwest in the Du Cane (MacLeod *et al.* 1961) and Mackintosh (Collins *et al.* 1981) mapsheet areas, conglomerates and siltstones are present in place of the pyritic mudstones known elsewhere in the Tasmania Basin. The nature of the pre-Parmeener basement was unknown in this central Tasmanian region until the work reported here.

The Hunterston Dome is of interest to hydrocarbon exploration in the Tasmania Basin, and was first drilled in August 1997 for Great South Land Minerals. The initial drilling, by a 15 cm down-hole hammer, went to a depth of 336 m. In July 2002 drilling recommenced with diamond coring (HQ, 63 mm diameter to 974 m and NQ, 45 mm diameter to base) to a total depth of 1324 m, passing through Parmeener sediments into a Precambrian basement. The drill core is stored at Mineral Resources Tasmania, Mornington Store. The location of the drill site is indicated in figure 1.

STRATIGRAPHY (FIG. 2)

Upper marine sequence (Late Permian)

Undifferentiated upper marine sequence 0–134 m

This section of the hole was produced by hammer drill and the resultant chip material shows little about this monotonous sequence of predominantly mudstone. Because of the lack of stratigraphic detail in this section it is unknown how much of the sequence has been displaced by movement associated with dolerite intrusion.

Dolerite (Jurassic)

Dolerite was encountered from 134 to 784.4 m, totalling 650.4 m thickness, and represents multiple intrusive events, evidenced by internal contacts between differing grainsize textures. The dolerite is massive and fine- to medium-grained. Baking effects on underlying Parmeener sediments are readily visible in the core sample for about 20 m beneath the margin of the dolerite. Vitrinite reflectance values from samples 65–85 m beneath the dolerite do not indicate significantly elevated temperatures.

Upper marine sequence (Early Permian)

Cascades Group correlate 784.4–848.5 m

The lower dolerite margin contacts directly with fossiliferous siltstones of the Cascades Group. From 784.4 to 811.5 m, is a baked fossiliferous siltstone, visible baking effects decreasing downward into grey bioturbated fossiliferous siltstone. Brachiopods, bivalves and bryozoans are abundant, with common fenestellid-dominant horizons. Fossils are thin-shelled and less common from 798 m. Thin, bioturbated, clay horizons are present at 801 m and 811 m. From 811.5 to 838.8 m, are bioturbated siltstone and sandy siltstone with

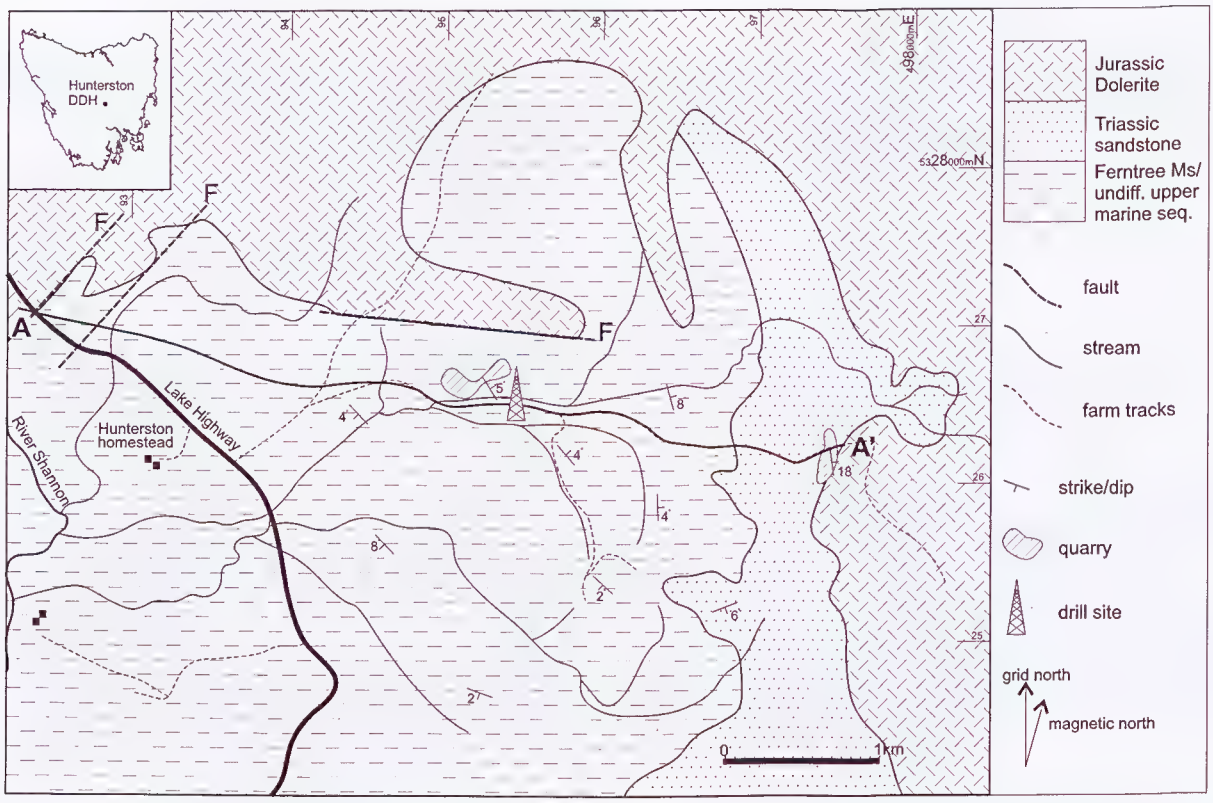


FIG. 1 — Locality map and geology in the immediate vicinity of the Hunterston DDH. A–A' approximate position of seismic line TB01-PA. See figure 7 for cross-section A–A'.

fossils in the upper part, and granules and scattered pebbles throughout. From 838.8–848.5 m are bioturbated pyritic mudstone and siltstone, with bioturbated sandstone and a prominent pebble horizon at 842.5 m. The lowermost part of this sequence is black mudstone with wispy bioturbation and heavy pyritisation.

The effects of contact metamorphism associated with the dolerite have destroyed much of the skeletal detail of the bryozoans, but a Bernacchian age is indicated, for the richly fossiliferous siltstones at 797.5 m, by the presence of *Levifenestella expansa* (Faunizones 2–5 of Clarke & Banks 1975) and *Stenopora berriedalensis* (Faunizones 4–10). The presence of Bernacchian species is in agreement with the Cascades Group in the Tunbridge Tier DDH where a probable Bernacchian age is indicated for the lower 45 m of Cascades beds (Reid 2003).

Freshwater beds (Early Permian)

Liffey Group 848.5–870.1 m

The Liffey Group is divided into three units within the Hunterston DDH: an upper carbonaceous fine-grained sand, middle sandy siltstone and lower carbonaceous fine sandstone. The uppermost unit, from 848.5 to 853.6 m, is of carbonaceous, silt-laminated and cross-bedded, fine-grained micaceous sandstone that is bioturbated at its upper boundary with the overlying Cascades Group correlate. Thin carbonaceous siltstone bands occur in the lower part, with a prominent coarse-grained sandstone with plant fragments at 850.45 m. The middle unit, from 853.6 to 862 m, is of thinly-laminated, carbonaceous, sandy siltstone. Pyritisation and soft sediment deformation are common, with the latter intense at 855.5 m. The siltstone becomes gritty at 860 m and grades into the lower unit, from 862 to 870.1 m. The lower unit is of carbonaceous, laminated, micaceous, fine-grained sandstone, with minor, soft carbonaceous siltstone horizons. The grain-size increases downward with medium- to coarse-grained sandstone over the last two metres. The base of the Liffey Group is sharp and conglomeratic at 870.1 m.

Lower marine sequence (Early Permian)

Bundella Mudstone correlate 870.1–900 m

From 870.1 m is a bioturbated, silty, pebbly, sandstone, fining rapidly to dark grey-black foraminiferal siltstone. Black siltstone grades to a grey bioturbated siltstone, typical of Bundella Mudstone, by 876 m. The main body of the Bundella Mudstone correlate is of bioturbated grey siltstone which becomes increasingly pebbly downwards. Fossil horizons are rare, containing brachiopods and trepostome bryozoans.

Conglomeratic beds 900–980 m

The typical fossiliferous lower Bundella Mudstone facies and Woody Island Siltstone are absent from the core, and are replaced by conglomerates, conglomeratic siltstones and pebbly siltstone. From 900 to 908.5 m are poorly-sorted, silty conglomerates and pebbly siltstones. Clasts are generally rounded, up to 7 cm in diameter, mostly of dolomite, chert and limestone. From 908.5 to 949 m, pebbly siltstone predominates, with isolated bands of conglomerate and conglomeratic siltstone. The siltstone becomes better-sorted and darker from 924 to 944 m. Bands of silty conglomerate and conglomeratic siltstone are common from 944 to 949 m. From 949 m, to the base of the Parmeener sequence at 980 m, conglomerate and conglomeratic sandstone dominate. Clasts are mostly of dolomite, with some sandstone and metamorphic clasts

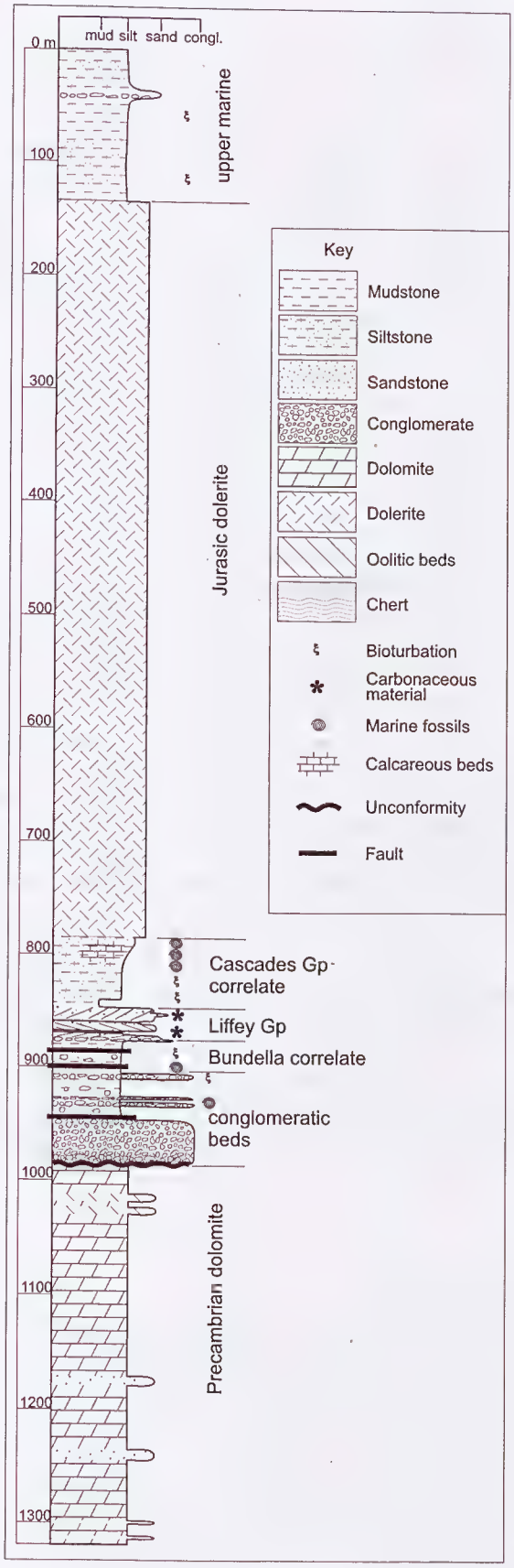


FIG. 2 — Schematic stratigraphic column of the Hunterston DDH.

occurring. Rounding is variably subangular to well-rounded, with isolated beds of well-sorted, well-rounded, conglomerate, within poorly-sorted subangular to rounded, conglomeratic sandstones. Poorly-sorted conglomeratic sandstones, with wispy carbonaceous silt bands, dominate the lowermost 18 m. The basal beds are dolomitic conglomerate with a sharp and steep erosional contact with a dolomite basement.

The lowermost conglomerates are poorly-sorted and may be termed diamictites. However, they are not the tillites typical to the Tasmania Basin. Their glacial origin cannot be proven and they are not correlated with the Wynyard Tillite.

Basement (Precambrian)

Precambrian Dolomite 980.5–1323.6 m

The sequence is dominated by grey to black fine-grained dolomite, the darker beds being finer grained. Minor green sandstone, and red and green chert beds occur, and the siltstone shows deformation throughout. Two small intervals at 1025 m and 1036 m have dark grey ooids approximately 5 mm across in a light grey matrix. Bedding planes vary from near horizontal to vertical and are rarely consistent for more than 500 mm. In most cases bedding is convoluted and in places shows slump structures. Stylolites were observed in a number of places outlined by graphitic material.

Much of the core is broken and crumbly but competent sections show complex calcite veining patterns. Many veins are broken and displaced by minor faulting. Two vein sets are observed, one fine and generally less than 1 mm thick, and the other 10–20 mm, both cross-cutting each other and the bedding. The larger calcite veins are more common below 1250 m.

The dolomite sequence is non-fossiliferous except for unidentified stromatolites at 1180 m, and apparent algal lamination at 1170 m. In a number of places core breakage may have occurred along algal laminated layers.

From 1041 m fine disseminated pyrite is present through the dolomite, and as crystalline coverings of fracture planes. Fine dissolution cavities are present, particularly in thicker calcite veins. Decomposed black clay occurs towards the bottom of the hole.

Textures become schistose from 1240 m, where a black sheen is visible on cleavage surfaces. Cleavage becomes crenulated and from 1320 m the core can be described as schist. The last two metres are partly decomposed with pyrite crystals up to 1 mm across.

The dolomite intersected at Hunterston can be lithologically correlated with the Black River Dolomite of northwestern Tasmania. The interbeds of green sandstone, small oolitic intervals and chert within the Hunterston core are similar to the Black River Dolomite (C.R. Calver, pers. comm.). The Black River Dolomite has been correlated with the Success Creek Group of western Tasmania (Brown 1989) and the Weld River Group of south-central Tasmania (Calver 1989). All these groups are recognised as Neoproterozoic (~750–650 Ma) (Calver 1998).

PALAEOGEOGRAPHY

The freshwater beds and upper marine sequence encountered in the Hunterston DDH are similar to these units elsewhere in Tasmania. However, the absence of Wynyard Tillite and the presence of conglomeratic facies, in place of the Woody Island Siltstone and part of the Bundella Mudstone, is of interest. To the east in the Tunbridge and Ross DDHs are thick sequences of tillite (Wynyard Tillite) overlain by pyritic pebbly mudstone and siltstone (Woody Island Siltstone). These areas are in closer proximity to Hunterston than the thick conglomeratic deposits observed in the Mackintosh area (Collins *et al.* 1981), or the thinner, but significant, conglomerates in the Du Cane area (MacLeod 1961). The absence of thick diamictites or identifiable tillite, and the presence of conglomeratic sequences at Hunterston in place of the Woody Island Siltstone, signifies a regional high, that may extend to the northwest, to link with that shown by Collins *et al.* (1981) (fig. 3). Whether the high is a series of peaks or a continuous southeast trending mountain range is unknown.

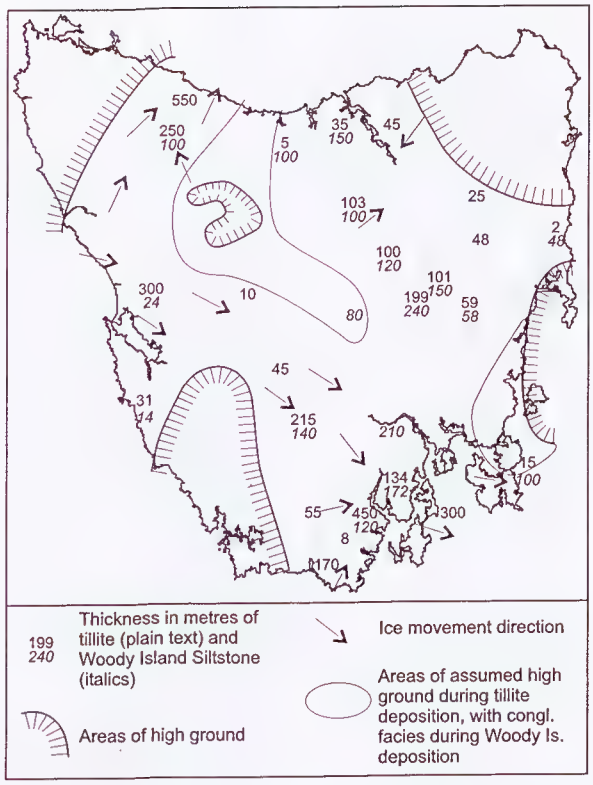


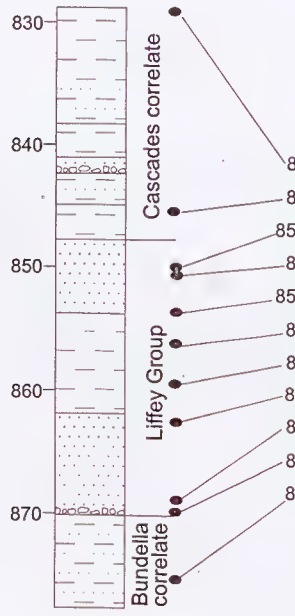
FIG. 3 — Palaeogeography of the Tasmania Basin, during deposition of the Wynyard Tillite (Carboniferous) and Woody Island Siltstone (late Carboniferous/early Permian. Updated from Clarke (1989), with additional ice movement indicators from Hand (1993). Extension of Mt Inglis area conglomerates into central area of basin based on drilling results of Hunterston DDH.

HYDROCARBON PROSPECTIVITY

Source rock

The absence of the Woody Island Siltstone removes this otherwise regionally extensive potential source rock from any hydrocarbon play within the immediate Hunterston area. The conglomeratic mudstones at this stratigraphic level, while often having a dark mud matrix, are not of source quality. Toward the base of the conglomeratic beds wispy carbonaceous mud lenses appear in the matrix, with moderate Total Organic Carbon (TOC) and Type I kerogens; however, these are too thin and discontinuous to contribute to a hypothetical hydrocarbon play. The Tasmanite Oil Shale, or abundant *Tasmanites,* found within the Woody Island Siltstone elsewhere in the Tasmania Basin, and of potential source quality, are also absent.

However, potential hydrocarbon source rocks are contained within the carbonaceous siltstones and sandstones of the Liffey Group. Discrete coal beds are not developed but mudstones with disseminated carbonaceous material, and plant fragments, show TOC levels up to 3.1% (fig. 4), comparable to non-coal beds in this unit elsewhere in the Tasmania Basin. Kerogen types are dominantly type III, as characterised by Hydrogen Index versus T_{max} plots.



	Reservoir		Reflectance			Rock Eval			Comments
	porosity %	perm. mD	inertinite	vitrinite	*vitrinite range*	TOC	T$_{max}$	S$_1$/S$_2$	
828.5			2.09	NA		1.25	492	0.6/.61	bioturbated carbonaceous siltstone
845.6						2.9	463	0.46/1.24	bioturb., carbonaceous pyritic siltstone
850.15						3.1	459	0.54/1.9	fine sand, with carb. silt lamination
850.5	0.9		2.10	1.28	0.90-1.55				sandstone, carb. lamination & oil inclusions
853.25	8.7	0.06							fine sand, with carb. silt lamination
856.5			2.10	1.06	0.94-1.26	2.35	464	0.38/1.84	carbonaceous siltstone, with oil inclusions
859.2						2.24	458	0.41/1.49	carbonaceous pyritic siltstone
862.9	4.1	0.04							fine sandstone, carbonaceous lamination
869.3	5.6	0.05							medium-coarse sandstone, oil inclusions
869.5			NA	1.23	1.11-1.31	2.2	464	0.55/1.51	coarse sandstone, woody frags, oil incl.
874.4			2.02	NA		1.26	447	0.36/1.01	carb., bioturb., siltstone, w. oil inclusions

FIG. 4 — Summary data for the Liffey Group and adjacent rocks. Data given for principal potential source and reservoir rocks.

Type III kerogens are gas prone, and their low atomic hydrogen to carbon ratio means they generate and expel less petroleum products than other kerogen types (Hunt 1996).

Samples from the Liffey Group and underlying and overlying marginal marine beds of the Bundella Mudstone and Cascades Group were analysed for vitrinite reflectance. Only the Liffey Group samples contained vitrinite in the dispersed organic matter (Cook 2003), all samples contained inertinite, and liptinite is absent. The basal contact of the dolerite sill complex is at 784.4 m, 44.1 m above the Cascades sample, 66.1 m, 72.1 m and 84.9 m above the Liffey Group samples and 90 m above the Bundella sample. The relative consistency in the reflectance of inertinite and vitrinite material (fig. 4) indicates that heating effects of contact metamorphism are negligible at these distances from the dolerite intrusion. The nature of the vitrinite also indicates that any alteration from contact metamorphism is mild, as carbonised organic matter is not present (Cook 2003).

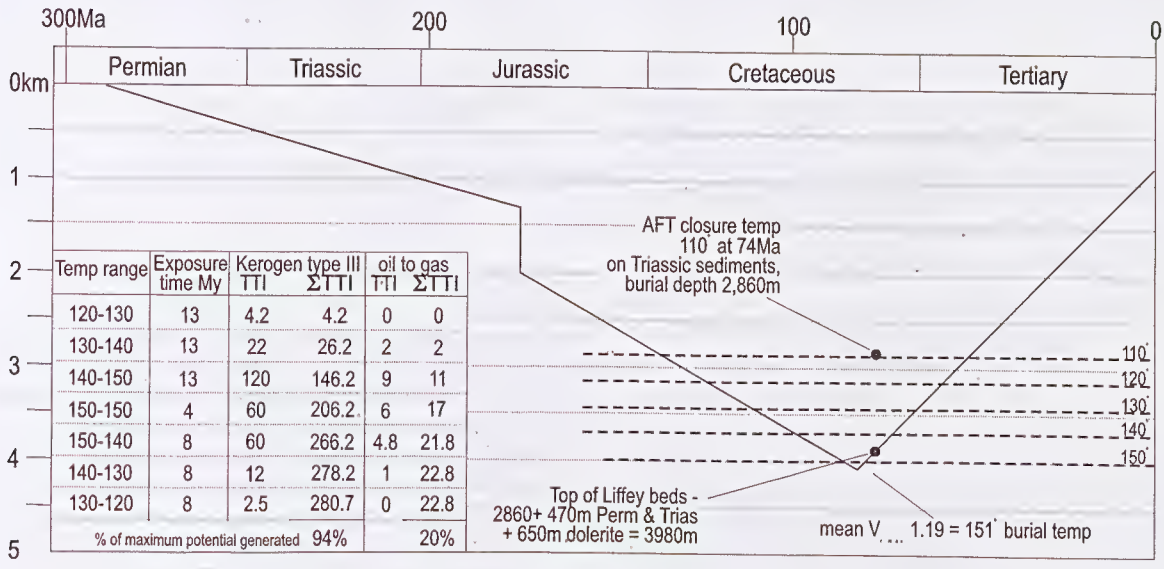
Calculated petroleum generation, using time-temperature index graphs (Hunt & Hennet 1992) based on the Arrhenius equation (TTI_{ARR}) (Wood 1988), is difficult to determine, as the total sedimentary overburden in the Hunterston region is not known. The thickness of Triassic sediments can be roughly assumed, but there is an unknown amount of upper Jurassic to Tertiary sediment. Burial profiles based on the known Permian to Jurassic overburden do not bury the Liffey Group to depths great enough for hydrocarbon generation. Yet the vitrinite reflectance values indicate maturity was achieved, with probably only a small increase from dolerite effects. The overburden required to account for vitrinite reflectance is consistent with cover rock erosion calculated from denudation rates given by Kohn *et al.* (2002). Given a mean vitrinite reflectance value of 1.19%, the corresponding burial temperature (from data in Barker & Pawlewicz 1994) would be approximately 151°C. Although there is debate over the thermal history of the Tasmania Basin (Leaman 2003) and the implication of apatite fission track data, maximum burial is here taken to have been reached in the mid-Cretaceous (O'Sullivan & Kohn 1997, Kohn *et al.* 2002). Constructing a theoretical burial curve to match a temperature maximum of 151°C, with mid-Cretaceous maximum burial, type III kerogens may have generated 94% of maximum potential hydrocarbon generation, and 20% petroleum may have cracked to gas (fig. 5). Type III kerogens generate only about 25.2% of carbon in their total TOC to oil and gas as the quantity of petroleum generated is determined by the hydrogen content of the kerogen (Hunt 1996). In this case the kerogen type reduces the overall potential productivity of the system, despite an otherwise favourable burial curve.

Reservoir rock

Traditional potential hydrocarbon reservoir rocks exist within the sandstones of the Liffey Group, as they do across much of the Tasmania Basin. However, in the Hunterston DDH, carbonate cementation is present in medium to coarse sandstone, and is later than both silica and clay, but may replace both (fig. 6). In many Liffey Group samples original quartz clasts have been eroded, and orthoclase feldspar has been pervasively replaced by calcite. In the Hunterston DDH carbonate cement is well-developed, and it is the late dissolution of carbonate that produces a secondary porosity. However, reduced connectivity of pore spaces has lowered permeability. Permeability in potential reservoir beds ranges between 0.04 and 0.06 mD.

It is postulated that dolerite intrusion has affected fluid chemistry, and the calcareous beds of the Cascades Group have contributed carbonate to the pore fluids, increasing pH, and resulting in carbonate precipitation in the more porous Liffey sandstones.

Some Liffey Group sandstones contain oil inclusions, within microfractures in both quartz and carbonate (Cook 2003). Oil inclusions form during crystallisation of



Temp range	Exposure time My	Kerogen type III TTI	Kerogen type III ΣTTI	oil to gas TTI	oil to gas ΣTTI
120-130	13	4.2	4.2	0	0
130-140	13	22	26.2	2	2
140-150	13	120	146.2	9	11
150-150	4	60	206.2	6	17
150-140	8	60	266.2	4.8	21.8
140-130	8	12	278.2	1	22.8
130-120	8	2.5	280.7	0	22.8
% of maximum potential generated			94%		20%

FIG. 5 — Theoretical burial profile and calculated hydrocarbon generation for Liffey Group beds, based on Time Temperature Index (TTI_{ARR}). Constraints on the burial profile are the known thickness of Permian sediments and Jurassic dolerite, and assumed thickness of Triassic sediments. Maximum burial depth plotted according to mean vitrinite reflectance maximum (Barker & Pawlewicz 1994) and assumed geothermal gradient of 35°/km. Time of maximum burial based on AFT closure temperature of 110°C in Triassic sediments (O'Sullivan & Kohn 1997).

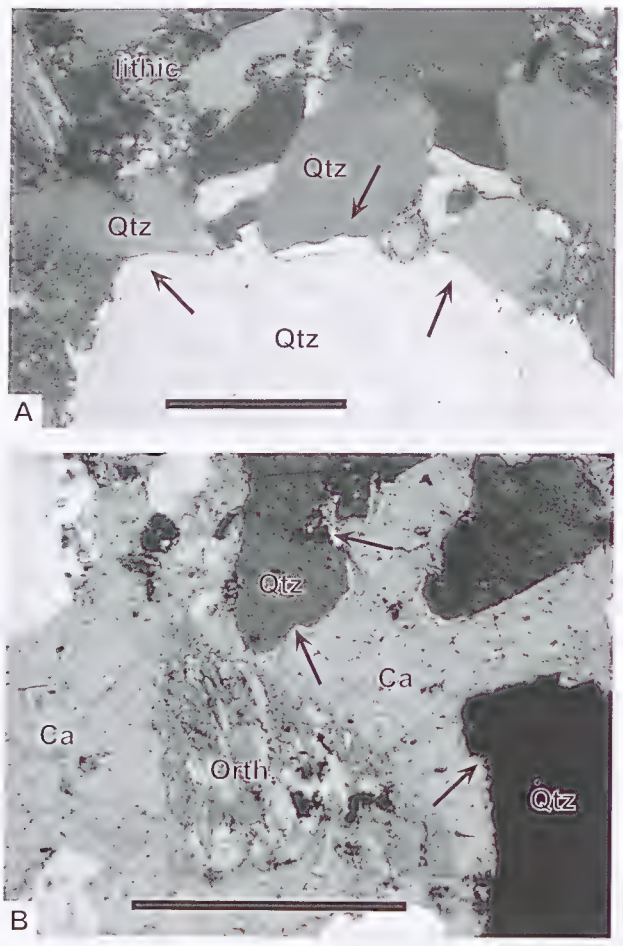


FIG. 6 — Diagenetic features of Liffey Group sandstone in the Hunterston DDH, all scale bars 0.5 mm. (A) 869.3 m polarised light view showing quartz overgrowths, with grain boundaries indicated by arrows. (B) 850.5 m polarised light view showing perthitic dissolution of orthoclase feldspar and dissolution of quartz cement and grains, and replacement with calcite cement indicated by arrows. Qtz = quartz, Ca = calcite, Orth = orthoclase feldspar, lithic = lithic clast.

diagenetic minerals, and through brittle deformation and fracturing of detrital and diagenetic grains during burial (George *et al.* 1996). The presence of oil inclusions in carbonate cement indicates hydrocarbon movement either during or after mid-Jurassic, probably after if maximum burial of source rocks was achieved in the Cretaceous.

Down-hole Fault Zones

There is potential for localised reservoirs within brecciated fault zones in the lower marine sequence. Several of these brecciated zones occur around 900 m depth, each with an associated 'halo' of carbonate dissolution, and replacement by silica, ranging from 0.5 to 10 m in thickness. The dissolution of carbonate material is assumed to be by fluids introduced along fault structures. The degree of brecciation is severe, and the high porosity and permeability led to loss of drilling pressure, indicating such horizons would be highly suitable reservoirs, providing there is a suitable seal on the fault away from the zone of dissolution.

Near the base of the Lower Parmeener Supergroup in the Hunterston DDH at 957 m, strong carbonate dissolution and siliceous replacement of a conglomerate, over 3 m, has not been brecciated and mean porosity is 16.9% while mean permeability is 6323 mD.

Structure

Figure 1 shows the local strike and dip of beds that form a dome-like structure. The drillhole was placed at the estimated central position of this structure. The Hunterston Dome is reflected at the surface in Permian and Triassic sediments, and was assumed to continue as a subsurface feature. The seismic data show the subsurface dip of the Parmeener beds as regionally flat lying. The seismic data also show the continuity of the eastern outcropping dolerite with the intrusion encountered between 134 and 784 m in the hole. On a regional scale it appears there is only one major dolerite body across the central Highlands, as partly shown in figure 7. The deformation of Triassic sandstones and the upper marine beds of the Parmeener Supergroup, producing the Hunterston Dome, either preceded or was coincident with dolerite intrusion. Dips adjacent to the dolerite contact east of the DDH site steepen towards the boundary, and may indicate bed drag effects.

Within the basement Precambrian dolomite complex, minor faulting and intersecting veining patterns noted in the core indicate a complex tectonic history and a number of episodes of movement. Bedding directions, where visible, repeatedly vary between near horizontal to vertical indicating that the drilled section passed through multiple folds. The extremely contorted bedding near the bottom of the hole may indicate proximity to a thrust plane. The presence of black clay, evidence of partial dissolution, in this region may be due to fluids introduced along a permeable thrust plane.

Permo-Carboniferous glacial erosion and retreat has produced conglomeratic beds of rounded pebbles of Precambrian dolomite, supported in a silty matrix, immediately on top of the massive Precambrian dolomite. A series of thrusts can be traced in the Fossey Mountains region of northern Tasmania (Woodward *et al.* 1993) and the existence of stacked thrusts in the area drilled has been interpreted from geophysical data (Leaman *et al.* 1973, Leaman 1989, 2001). In the Hunterston area the geology of associated thrust blocks is unknown.

CONCLUSIONS

The Parmeener Supergroup stratigraphy in the Hunterston DDH includes undifferentiated upper marine sequence, possibly part Ferntree Mudstone, the Cascades Group, freshwater Liffey Group and Bundella Mudstone as expected. A thick, 650 m, multiple dolerite intrusion is present between the upper undifferentiated marine sequence and the Cascades Group. The presence of basal conglomerates in place of Woody Island Siltstone, and Wynyard Tillite, proved the extension of Mackintosh–Du Cane regional high to the northwest through this central part of the Tasmania Basin. Basement to the Parmeener Supergroup is Precambrian dolomite, with its closest lithological correlate near Smithton in far northwest Tasmania.

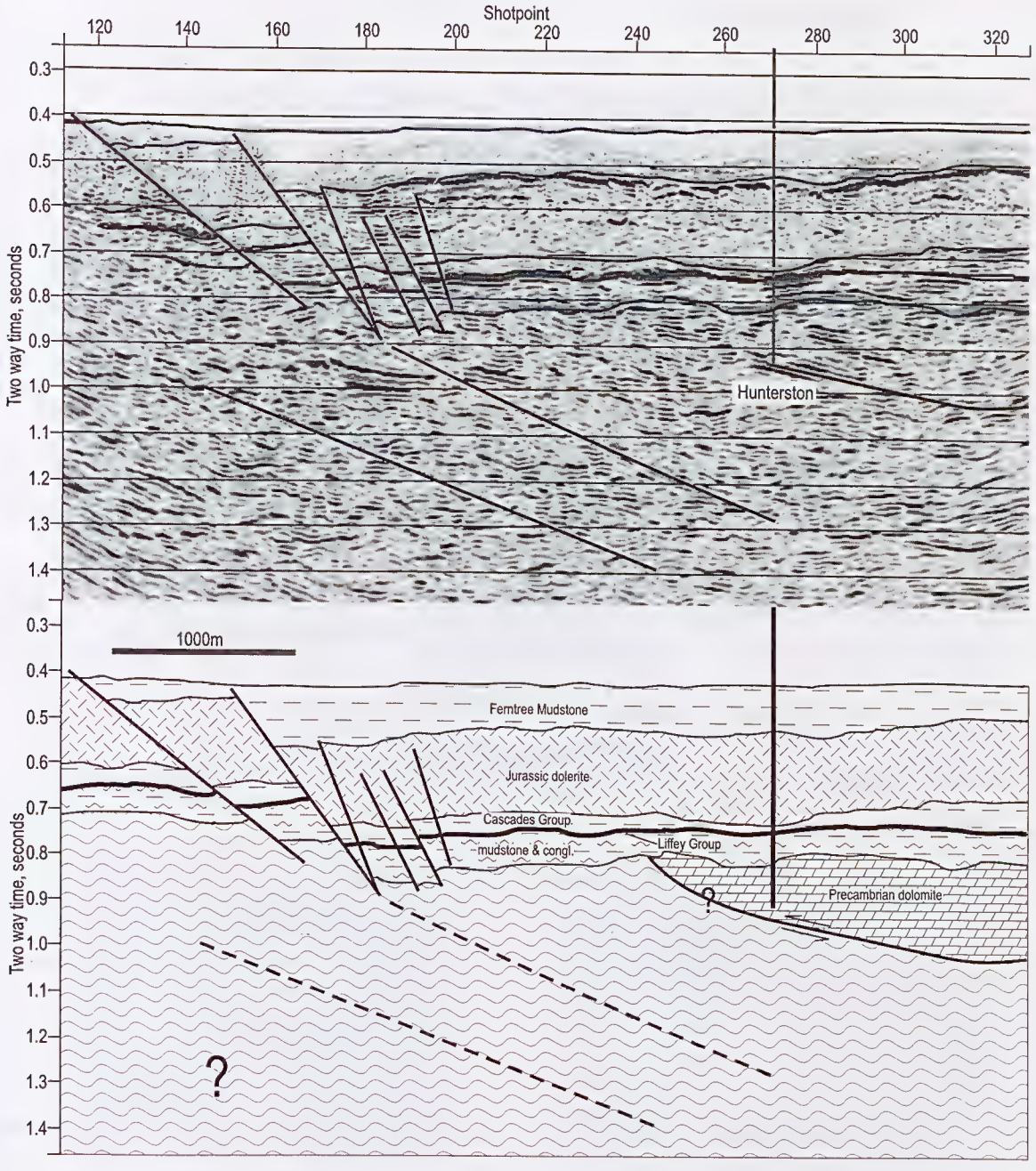


FIG. 7 — Seismic profile line TB01-PA (shown in fig. 1 as A–A'). Geological interpretation based on seismic data and drillhole correlation.

The absence of the Woody Island Siltstone, a potential hydrocarbon source rock, and dispersed or concentrated *Tasmanites* commonly contained within it, reduces the previously assumed distribution of this unit. Potential hydrocarbon source rocks exist within the freshwater Liffey Group, and a calculated burial curve and time temperature index indicates the potential for hydrocarbons to have been generated. Oil inclusions within sandstones of the Liffey Group indicate that hydrocarbons have migrated through the section, either from the reservoir unit itself, or from adjacent source areas. The timing of possible oil migration is not well defined, but is mid-Jurassic or younger. Carbonate precipitation has reduced reservoir quality within the Liffey Group.

Despite a thick dolerite intrusion, direct heating effects are confined to the immediate (lower) boundary. As little as 44 m from the 650 m multiple dolerite intrusion vitrinite reflectance values are apparently unaffected.

ACKNOWLEDGEMENTS

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REFERENCES

Barker, C.E. & Pawlewicz, M.J., 1994: Calculation of vitrinite reflectance from thermal histories and peak temperatures, a comparison of methods. *In* Mukhopadhyay, P.K. & Dow, W.G. (Eds): *Vitrinite Reflectance as a Maturity Parameter. Applications and Limitations. ACS Symposium Series 570.* American Chemical Society: 216–229.

Brown, A.V., 1989: Eo-Cambrian–Cambrian. *In* Burrett, C.F. & Martin, E.L. (Eds): *Geology and Mineral Resources of Tasmania. Geological Society of Australia Special Publication* 15: 47–83.

Calver, C.R., 1989: The Weld River Group: A major upper Precambrian dolomite sequence in southern Tasmania. *Papers and Proceedings of the Royal Society of Tasmania* 123: 43–53.

Calver, C.R., 1998: Isotopic stratigraphy of the Neoproterozoic Togari Group, Tasmania. *Australian Journal of Earth Sciences* 45: 865–874.

Clarke, M.J., 1989: Lower Parmeener Supergroup. *In* Burrett, C.F. & Martin, E.L. (Eds): *Geology and Mineral Resources of Tasmania. Geological Society of Australia Special Publication* 15: 295–309.

Clarke, M.J. & Banks, M.R., 1975: The stratigraphy of the lower (Permo-Carboniferous) parts of the Parmeener Super-Group, Tasmania. *In* Campbell, K.S.W. (Ed.): *Gondwana Geology.* International Gondwana Symposium (3): 453–467.

Collins, P.L.F., Gulline, A.B. & Williams, E., 1981: *Mackintosh. Geol. Atlas 1 Mile Series.* Geological Survey Explanatory Report, Sheet 44 (8014N). Tasmania Department of Mines: 146 pp.

Cook, A.C., 2003: Organic petrology of some core samples from the Permian of Tasmania. Unpublished Report. Keiraville Konsultants Pty Ltd, 12 pp.

Fairbridge, R.W., 1949: The geology of the country around Waddamana, central Tasmania. *Papers and Proceedings of the Royal Society of Tasmania* (1949): 111–151.

Forsyth, S.M., 1989: *Interlaken. Geol. Atlas 1:50,000 Series.* Geological Survey Explanatory Report, Sheet 61 (8313N). Tasmania Department of Mines: 78 pp.

George, S.C., Lisk, M., Eadington, P.J., Quezada, R.A., Krieger, F.W. & Greenwood, P.F., 1996: Comparison of palaeo oil charges with currently reservoired hydrocarbons using the geochemistry of oil-bearing fluid inclusions. *Society of Petroleum Engineers, Asia Pacific Oil and Gas Conference, 28-31 October 1996, Adelaide, SPE paper 36980:*159–171.

Hand, S.J., 1993: Palaeogeography of Tasmania's Permo-Carboniferous glacigenic sediments. *In* Findlay, R.H., Unrug, R., Banks, M.R. & Veevers, J.J. (Eds): *Assembly, evolution and dispersal. Proceedings of the Gondwana Eight Symposium* 8. International Gondwana Symposium, International: 459–469.

Hunt, J.M., 1996: *Petroleum geochemistry and geology.* W.H. Freeman and Company, New York: 743 pp.

Hunt, J.M. & Hennet, R.J.-C., 1992: Modeling petroleum generation in sedimentary basins. *In* Whelan, J. & Farrington, J. (Eds): *Organic matter: Productivity, accumulation and preservation in recent and ancient sediments.* Columbia University Press, New York: 20–52.

Jago, J.B., 1971: Geology of the Maydena Range. *Papers and Proceedings of the Royal Society of Tasmania* 106: 45–57.

Kohn, B.P., Gleadow, A.J.W., Brown, R.W., Gallagher, K., O'Sullivan, P.B. & Foster, D.A., 2002: Shaping the Australian crust over the last 300 million years: insights from fission track thermotectonic imaging and denudation studies of key terranes. *Australian Journal of Earth Sciences* 49: 697–717.

Kohn, B.P., Gleadow, A.J.W., Brown, R.W., Gallagher, K., O'Sullivan, P.B. & Foster, D.A., 2003: Reply. Shaping the Australian crust over the last 300 million years: Insights from fission track thermotectonic imaging and denudation studies of key terranes. *Australian Journal of Earth Sciences* 50: 646–650.

Leaman, D.E., 1989: The gravity field. *In* Burrett, C.F. & Martin, E.L. (Eds): *Geology and Mineral Resources of Tasmania. Geological Society of Australia Special Publication* 15: 451–455.

Leaman, D.E., 2001: *Step into history in Tasmanian reserves.* Leaman Geophysics, Hobart: 416 pp.

Leaman, D.E., 2003: Discussion. Shaping the Australian crust over the last 300 million years: insights from fission track thermal imaging and denudation studies of key terranes. *Australian Journal of Earth Sciences* 50: 645–646.

Leaman, D.E., Symonds, P.A. & Shirley, J.E., 1973: Gravity survey of the Tamar Region, Northern Tasmania. *Geological Survey Tasmania, paper 1.*

Macleod, W.N., Jack, R.H. & Threader, V.M., 1961: *DU CANE. Geol. Atlas 1 Mile Series.* Geological Survey Explanatory Report, K55-11-52. Tasmania Department of Mines: 39 pp.

O'Sullivan, P.B. & Kohn, B.P., 1997: Apatite fission track thermochronology of Tasmania. *Record Australian Geological Survey Organisation* 1997/35.

Reid, C.M., 2003: Permian Bryozoa of Tasmania and New South Wales: systematics and their use in Tasmanian biostratigraphy. *Memoirs of the Association of Australasian Palaeontologists* 28: 133 pp.

Wood, D.A., 1988: Relationships between thermal maturity indices calculated using Arrhenius equation and Lopatin method: Implications for petroleum exploration. *American Association Petroleum Geologists Bulletin* 72: 115–134.

Woodward, N.B., Gray, D.R. & Elliot, C.G., 1993: Repeated Palaeozoic thrusting and allochthoneity of Precambrian basement, northern Tasmania. *Australian Journal of Earth Sciences* 40: 297–311.

(accepted 24 November 2003)

OBITUARY
SAMUEL WARREN CAREY, AO, 1911–2002

by Patrick G. Quilty and Maxwell R. Banks

QUILTY, P.G. & BANKS, M.R. 2003 (19:xii): Obituary, Samuel Warren Carey, AO, 1911–2002: *Papers and Proceedings of the Royal Society of Tasmania* 137: 95–98. ISSN 0080-4703. School of Earth Sciences, University of Tasmania, Private Bag 79, Hobart, Tasmania, 7001, Australia.

Emeritus Professor
S. Warren Carey, AO

The Royal Society of Tasmania lost one of its members of long standing on 20 March 2002 when Emeritus Professor Samuel Warren Carey died in Hobart at the age of 90.

He was born near Campbelltown, New South Wales, and attended Campbelltown Primary School before secondary education at Canterbury High School. He obtained an Exhibition to the University of Sydney, and a Teachers' Training College Scholarship, commencing in 1929. He enrolled in Geology I as a fourth subject on the advice of one of his teachers, and this determined the direction of his career. He came under the influence of Prof. Sir T.W. Edgeworth David who had recently retired, and he encountered for the first time the concept of continental drift as a mechanism for explaining important aspects of Southern Hemisphere geology. He graduated with First Class Honours in 1932 and proceeded to a Masters degree, in 1934, both degrees based on field studies of the area around Werris Creek, near Tamworth in New South Wales. The rocks are about 300 million years old (Carboniferous) and not currently very active tectonically. Employment with Oil Search in Papua New Guinea introduced him to active modern tectonics where volcanic eruptions and great earthquakes were part of life. His New Guinea experiences led to a D.Sc. degree from the University of Sydney in 1939. Life in the New Guinea environment influenced greatly his view of the Earth as a dynamic planet and later helped him explain geological features he saw elsewhere, for example — in excavations for buildings and roads at the University of Tasmania and along the foreshore at Taroona.

During World War II, Carey was a commando in Z Force in which he had an exciting and typically unorthodox military career (written up in several books). As the war effort was winding down, he took the opportunity to come to Tasmania as Government Geologist. He accepted an appointment as Foundation Professor of Geology at the University of Tasmania, a post he held from 1946 until his retirement at the end of 1976.

He had an important influence on Tasmanian geology through his publications as Government Geologist, and his consultancy to the Hydro-Electric Commission. He invited leading geologists, such as R. Fairbridge, E.D. Gill, R. Prider, C. Teichert and A. Voisey, to be involved in unravelling the geological history of this state.

He attracted to Tasmania many of the world's leading geologists by convening of a series of topical symposia on issues such as continental drift, dolerite, syntaphral tectonics and diagenesis, and glacial marine sedimentation. These also led to invitations to him to address many leading conferences in Australia and overseas.

Some see Carey as one of the greatest geologists of all time, one who could grasp the 'big picture' to a degree matched by very few. He is well-remembered as a 'larger than life' figure for his vision and the originality of his views. His ability to absorb, remember and integrate vast quantities of data was one of his greatest characteristics and a feature that was daunting to his colleagues. He was arguably the internationally most-renowned academic ever to grace the halls of the University of Tasmania. In these days of computer modelling and desk-based geology, some suggest that it is unlikely that we will see his equal again.

He will go down in history as one who had a major influence on global science through his enthusiastic

advocacy of the unorthodox concept of continental drift and his role in having it accepted — it is now part of orthodoxy. Observations made during his continental drift studies convinced him that the Earth has expanded. This view has not received general acceptance but does have a vocal group of strong adherents.

Perhaps his greatest legacy is the attitude that he instilled in his many students. Typically, students will forget most of their university lecturers, but they will not forget Carey. He was inspirational. About 60% of those students who did Geology I (as terminology then had it) went on to Geology II, an unusually high figure. He was an extrovert who challenged students to question any view that was seen as orthodox or stated to be true because the exponent was an 'expert'. "We are blinded by what we think we know; disbelieve if you can."

He had several opportunities to leave Tasmania and move to larger, 'more prestigious' institutions but he stayed in the smaller university where he believed strongly that he could develop novel ideas more readily, without the institutional orthodoxy that characterises many large departments.

Carey was not only an academic; he was a parachutist, a strong supporter of Legacy and active in the affairs of ex-service organisations. He founded the Caverneering Club of Tasmania. In 'retirement' he was as active as ever and produced books examining the universe and cosmos, and the place of humanity and the earth in the broader scheme of things.

The list of his awards is long. He was an honorary life member and medal recipient of some of the world's leading geological institutions. After a fiery relationship with the Australian Academy of Science, he finally accepted Fellowship. He was appointed an Officer of the Order of Australia (AO) shortly after retirement. He is the subject of several portraits and sculptures.

Carey had very close associations with the Royal Society of Tasmania over several decades. He was Senior Vice President in 1950–51, served three terms as a member of Council, and was a member of the Standing Committee of Council for some years. He published several papers in the *Papers and Proceedings* of the Society (marked with an asterisk in the bibliography), including the important work on the orocline concept in tectonics. He was himself a regular speaker at Society meetings for a quarter of a century, both in Hobart and to the Northern Branch, and was instrumental in introducing a number of interstate and overseas speakers. As a recipient of the Society's R.M. Johnston Medal, he addressed the Society on 'A Philosophy of the Earth and Universe'; the address was subsequently published in the Society's journal in 1978.

He is remembered by many former students and staff for the influence on their careers and, more broadly, on their mental attitudes. Members of the Royal Society of Tasmania and other community organisations will recall his contribution to their understanding of the island on which we live and, more widely, of the broader features and history of the earth.

He is survived by his wife, Austral (Robson), four children (Tegwen Alice, Robyn, David and Harley), seven grandchildren and two great-grandchildren.

For a fuller account of his life and significance, see Quilty & Banks (2003).

REFERENCE

QUILTY, P.G. & BANKS. M.R., 2003: Samuel Warren Carey 1911–2002. *Historical Records of Australian Science* 14: 313–335.

BIBLIOGRAPHY

CAREY, S.W., 1933: Water divining. *Sydney University Science Journal* xii: 17, 18.

CAREY, S.W., 1934: The geological structure of the Werrie Basin. *Proceedings of the Linnean Society of New South Wales* 49: 351–374.

CAREY, S.W., 1934: Notes on the implications of the irregular strike lines of the Mooki Thrust System. *Proceedings of the Linnean Society of New South Wales* 49: 375–379.

CAREY, S.W., 1935: Note on the Permian sequence in the Werrie Basin. *Proceedings of the Linnean Society of New South Wales* 50: 447–486.

CAREY, S.W., 1937: The Carboniferous sequence in the Werrie Basin. *Proceedings of the Linnean Society of New South Wales* 52: 341–376.

CAREY, S.W. & BROWNE, W.R., 1938: Review of the Carboniferous stratigraphy, tectonics and palaeogeography of New South Wales and Queensland. *Journal and Proceedings of the Royal Society of New South Wales* 71: 591–614.

CAREY, S.W., 1938: The morphology of New Guinea. *The Australian Geographer* 3(5): 3–30.

CAREY, S.W. & OSBORNE, G.D., 1938: Preliminary note on the nature of the stresses involved in the Late Palaeozoic diastrophism in New South Wales. *Journal and Proceedings of the Royal Society of New South Wales* 72: 199–208.

CAREY, S.W., 1945: Notes on Cretaceous strata in the Purari Valley, Papua. *Proceedings of the Royal Society of Victoria* 56: 123–130.

CAREY, S.W., 1947: Report of the Government Geologist. *Report of the Director of Mines Tasmania (1945)*: 21–29.

CAREY, S.W., 1947: Occurrence of tillite on King Island. *Report of the 25th Congress of the Australian and New Zealand Association for the Advancement of Science, 1945*: 349.

CAREY, S.W., 1947: Geology of the Launceston District. *Records of the Queen Victoria Museum* 11: 31–46.

HILLS, C.L. & CAREY, S.W., 1949: Geology and mineral industry. *ANZAAS Handbook for Tasmania:* 21–44.

*CAREY, S.W. & SCOTT, B., 1952: Revised interpretation of the geology of the Smithton district of Tasmania. *Papers and Proceedings of the Royal Society of Tasmania* 86: 63–70.

CAREY, S.W., 1953: Geological structure of Tasmania in relation to mineralization. *In* Edwards, A.B. (Ed.): *Geology of Australian Ore Deposits: Fifth Empire Mining Congress* 1: 1108–1128.

*CAREY, S.W. & SCOTT, B., 1954: Native copper at Smithton – a correction. *Papers and Proceedings of the Royal Society of Tasmania* 88: 271, 272.

CAREY, S.W., 1954: The rheid concept in tectonics. *Journal of the Geological Society of Australia* 1: 67–117.

*CAREY, S.W., 1954: Correlation of the post-Triassic history of Tasmania with secular variation of temperature and viscosity of the sub-crust. *Papers and Proceedings of the Royal Society of Tasmania* 88: 189–191.

CAREY, S.W., 1954: The geoflex concept and the origin of the Indian Ocean. *Report of the Second Pan Indian Ocean Science Association Congress (Perth)*, Sect. C (1): 1.

*CAREY, S.W. & BANKS, M.R., 1954: Lower Palaeozoic unconformities in Tasmania. *Papers and Proceedings of the Royal Society of Tasmania* 88: 245–269.

CAREY, S.W., 1954: Fluid geotectonics. *News Bulletin of the Geological Society of Australia* 2(2): 1–3.

CAREY, S.W., 1955: Wegener's South American-African assembly, fit or misfit? *Geological Magazine* 92: 196–200.

*CAREY, S.W., 1955: The orocline concept in geotectonics. *Papers and Proceedings of the Royal Society of Tasmania* 89: 255–288.

CAREY, S.W., 1955: A new record of glacial grooving near Queenstown, Tasmania. *Australian Journal of Science* 17: 176.

CAREY, S.W., 1958: The tectonic approach to continental drift. *In* Carey, S.W. (Ed.): *Continental Drift: a symposium.* University of Tasmania, Hobart: 177–355.

CAREY, S.W., 1958: The isostrat, a new technique for the analysis of the structure of the Tasmanian Dolerite. *In* Carey, S.W. (Ed.): *Dolerite:* a *Symposium,* University of Tasmania, Hobart: 130–164.

CAREY, S.W., 1958: Relation of basic intrusions to thickness of sediments. *In* Carey, S.W. (Ed.): *Dolerite:* a *Symposium,* University of Tasmania, Hobart: 165–169.

CAREY, S.W., 1958: Note on the columnar jointing in Tasmanian dolerite. *In* Carey, S.W. (Ed.): *Dolerite:* a *Symposium,* University of Tasmania, Hobart: 229, 230.

CAREY, S.W., 1959: North–south asymmetry of the Earth's figure. *Science* 130: 978, 979.

CAREY, S.W., 1959: The tectonic approach to the origin of the Indian Ocean. *Proceedings of the Third Pan Indian Ocean Science Association Congress* (*Madagascar*): 171–228.

CAREY, S.W., 1960: The strength of the Earth's crust. *Transactions of the New York Academy of Science* ser. 11, 22: 303–312.

CAREY, S.W. & AHMAD, N., 1961: Glacial marine sediments – their environment and nomenclature. *In* Raasch, G.E. (Ed.): *Geology of the Arctic, Proceedings of the First International Symposium on Arctic Geology* University of Toronto Press, Toronto: 865–894.

CAREY, S.W., 1961: Palaeomagnetic evidence relevant to a change in the Earth's radius. *Nature* 190: 36.

CAREY, S.W., 1962: Folding. 3rd Honorary Anniversary Address. *Journal of the Alberta Society of Petroleum Geologists* 10(3): 95–144.

CAREY, S.W., 1962: Plegamiento... *Extracto de Notas y Communicaciones del Instituto Geologico y Minero de España* 74: 75–142.

CAREY, S.W., 1962: Scale of geotectonic phenomena. *Journal of the Geological Society of India* 3: 97–105.

CAREY, S.W., 1962: Escala de los Fenomenos Geotectonicos. *Extracto de Notas y Communicaciones del Instituto Geologico y Minero de España* 72: 277–288.

CAREY, S.W., 1963: The asymmetry of the Earth. Presidential address, ANZAAS Sec. C. *Australian Journal of Science* 25: 369–383, 479–488.

CAREY, S.W., 1963: Syntaphral tectonics. *In* Carey S.W. (Ed.): *Syntaphral Tectonics and Diagenesis a Symposium.* University of Tasmania, Hobart: B1–7.

CAREY, S.W., 1967: 2000 A.D. – Prognosis. *Medical Journal of Australia* 1: 1235–1242.

CAREY, S.W., 1967: Orthodoxy, heresy and discovery. Stanley Memorial Lecture. *Annual Report and Proceedings of the Papua and New Guinea Science Society* 18: 45–59.

CAREY, S.W., 1969: Tectonic framework of the Sydney Basin. *In* Engel, B.A. (Convenor): *Advances in the Study of the Sydney Basin.* Abstracts of the Fourth Newcastle Symposium. University of Newcastle, Newcastle: 53–59.

CAREY, S.W., 1970: Australia, New Guinea and Melanesia in the current revolution in concepts of the evolution of the Earth. Presidential address, 42nd ANZAAS Congress, Port Moresby. *Search* 1: 178–189.

CAREY, S.W., 1972: The face of the Earth. *Australian Natural History* 17: 254–257.

CAREY, S.W., 1973: Major features of the Pacific and the "New Global Tectonics". *In* Coleman, P.J. (Ed.): *The Eastern Pacific: Island Arcs, Marginal Seas, Geochemistry.* University of W.A. Press, Perth: 103, 104.

CAREY, S.W., 1973: Review of "A global approach to geology: the background of a mineral exploration strategy based on significant form in the patterning of the Earth's crust" by B.B. Brock. *Tectonophysics* 18: 391–393.

CAREY, S.W., 1973: Non Uniformitarianism. 4th Bertrand Russell Memorial Lecture, Flinders University, *Flinders Science Journal* 1(1973): 2–17.

CAREY, S.W., 1975: The expanding earth – an essay review. *Earth Science Reviews* 11: 105–143.

CAREY, S.W., 1975: Tectonic evolution of south-east Asia. *Fourth Indonesian Petroleum Congress* Preprint 1: 1–31.

CAREY, S.W., 1975: Palaeomagnetism and earth expansion. *Chayanica Geologica* 1: 152–195.

CAREY, S.W., 1975: Earth expansion: the face of the earth; the necessity of expansion; the subduction myth. *In* Messel, H. & Butler, S.T. (Eds): *Our Earth.* Shakespeare Head Press, Sydney: 105–167.

CAREY, S.W.,1975: Review of "Gravity and tectonics" (the van Bemmelen Volume). De Jong, K.A. & Scholten, R. (Eds): *Tectonophysics* 27: 297, 298.

CAREY, S.W., 1975: The subduction myth. *South East Asia Petroleum Association Proceedings* 11: 41–69.

CAREY, S.W., 1976: *The Expanding Earth.* Elsevier, Amsterdam: 488 pp.

*CAREY, S.W., 1978: A philosophy of the earth and universe. *Papers and Proceedings of the Royal Society of Tasmania* 112: 5–19.

CAREY, S.W., 1980: Causes of sea-level oscillations. *Proceedings of the Royal Society of Victoria* 92: 13–17.

CAREY, S.W., 1981: *The Expanding Earth – a Symposium.* Earth Resources Foundation, Sydney: 423 pp.

CAREY, S.W., 1981: Evolution of beliefs on the nature and origin of the earth. Convener's introduction, *In* Carey, S.W. (Ed.): *The Expanding Earth – a Symposium.* Earth Resources Foundation, Sydney: 3–7.

CAREY, S.W., 1981: Tethys and her forebears. *In* Carey, S.W. (Ed.): *The Expanding Earth – a Symposium.* Earth Resources Foundation, Sydney: 169–187.

CAREY, S.W., 1981: Earth expansion and the null universe. *In* Carey, S.W. (Ed.): *The Expanding Earth – a Symposium.* Earth Resources Foundation, Sydney: 367–396.

CAREY, S.W., 1981: The necessity for Earth expansion – Convener's review. *In* Carey, S.W. (Ed.): *The Expanding Earth – a Symposium.* Earth Resources Foundation, Sydney: 375–393.

CAREY, S.W., 1982: Genesis of the Himalayan system from Turkey to Burma. *Miscellaneous Publications of the Geological Survey of India* 1: 401–416.

CAREY, S.W., 1986: Genesis of Proterozoic banded-iron formation. *Journal of the Geological Society of India* 18: 223–226.

CAREY, S.W., 1986: Diagenetic krikogenesis. *In* Wezel, F.C. (Ed.): *The Origin of Arcs.* Elsevier, Amsterdam: 1–40.

CAREY, S.W., 1986: *La terra in espansione,* G. Scaleri (trans.): Laterza, Roma-Bari: 346 pp.

CAREY, S.W., 1986: Geotectonic setting of Australasia. *In* Glenie, R.C. (Ed.): *Second South-Eastern Australian Oil Exploration Symposium.* Petroleum Exploration Society of Australia, Melbourne: 3–25.

CAREY, S.W., 1987: Tethys and her forebears, *In* McKenzie, K.G. (Ed.): *Shallow Tethys 2.* Balkema, Rotterdam: 3–30.

CAREY, S.W., 1988: *Theories of the Earth and Universe: a History of Dogma in the Earth Sciences.* Stanford, Stanford University Press, Stanford: 413 pp.

CAREY, S.W., 1990: Knight Errant of Science. *In* Branagan, D.F. (Ed.): *Sir Edgeworth David Memorial Oration.* Australasian Mineral Heritage Trust and others, Brown, Prior and Anderson, Burwood: 1–54.

CAREY, S.W., 1990: Fifty years of oil search. *In* Carman, G.J. & Carman, Z. (Eds): *Petroleum Exploration in Papua New Guinea.* PNG Chamber of Mines and Petroleum, Port Moresby: 17–26.

CAREY, S.W., (as Keri, U.) 1991: V poiskakh zakonomernstei razvitiia zemli i vselennoi: istoriia dogm v naukakh o zemle. Borisova, B.A., Kutuzovoi, N.I. & Antilova, M.P. (Transl.). Mir, Moscow: 447 pp.

CAREY, S.W., 1996: *Earth, Universe, Cosmos.* University of Tasmania Press, Hobart: 258 pp.

(accepted 24 November 2003)

ERRATA

1.

RICKARDS, R.B., HILLS, P.B., BANKS, M.R. & MACDONALD, G., 2002 (31:xii): The significance of a new locality for *Monograptus thomasi* (Early Devonian) southwest of Beaconsfield, Tasmania, and of the Corn Hill Formation. *Papers and Proceedings of the Royal Society of Tasmania* 136: 7–16.

The image printed as plate 1B on page 9 of Volume 136 was that of *Allocasuarina crassa* not, as intended, of a rock specimen from Leviathan Hill. The image should have been that reproduced here.

PLATE 1
(B) Bouma units D and E with some C; convolute bedding, pillow structure and flames, Corn Hill Formation, Leviathan Hill, x0.9.

2.

Albert Deverell of Kimberley, Tasmania 7304, did not give his permission to be cited as a co-author of the paper "Tasmanian aborigines and DNA" published in Volume 136 of the *Papers and Proceedings of the Royal Society of Tasmania.*

The citation of this paper is amended to:
PRESSER, J. C., REDD, A. J. & STONEKING, M., 2002 (31:xii): Tasmanian Aborigines and DNA. *Papers and Proceedings of the Royal Society of Tasmania* 136: 35–38.

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